

DOCUMENT RESUME

ED 148 594

SE 023 427

AUTHOR Kennedy, Thomas G., Ed.; Hernbrode, William R., Ed.
 TITLE Teachers Resource Guide for Environmental Education.
 INSTITUTION Arizona State Dept. of Education, Phoenix.
 PUB DATE [77]
 NOTE 338p.; Not available in hard copy due to colored pages throughout entire document
 EDRS PRICE MF-\$0.83 Plus Postage. HC Not Available from EDRS.
 DESCRIPTORS Curriculum Guides; *Elementary Secondary Education; *Environmental Education; *Instructional Materials; *Interdisciplinary Approach; *Learning Activities; Natural Resources; Resource Materials; Science Education; Teaching Guides; Values

ABSTRACT

This guide is divided into seven major sections, each representing one of the following fundamental natural resources: (1) soil, (2) air, (3) water, (4) vegetation, (5) wildlife, (6) minerals, and (7) man. Within each of the seven major sections, there are three subsections which provide the following: (1) Background Information; (2) Suggestions and Activities; (3) Additional Resources. The guide is designed as a basis for developing a sound environmental ethic among students in grades K-12. It represents a resource of information, suggestions, and activities for supplementing an existing curriculum. The activities are appropriate for several disciplines, including science, mathematics, social studies, fine arts, language arts, and industrial arts and vocational education. Some illustrations are given. (Author/HA)

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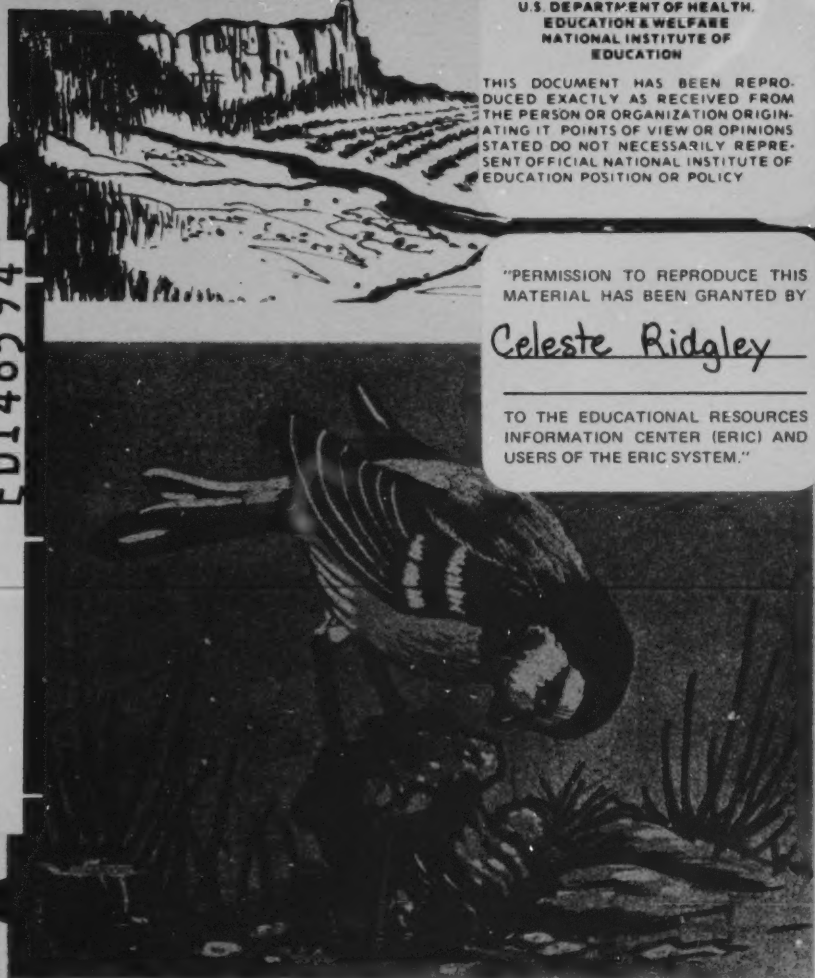
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Arizona Department of Education

TEACHERS RESOURCE GUIDE — for — ENVIRONMENTAL EDUCATION

Carolyn Warner, Superintendent

SE 023 427



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PREFACE

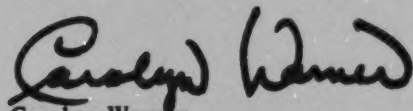
Environmental education contributes toward citizenry that is *knowledgeable* concerning the natural environment and its associated problems, *aware* of realistic and economic solutions to these problems, and *motivated* to work toward their solution. While it is not the intent of this document to cover all phases of environmental education, the activities and background information all have one purpose in common; to provide you with suggestions for helping teach the concept that:

Man is an inseparable, integral part of a system that consists of man, culture, and the natural environment and that man has the ability to alter the interrelationships of this system.

The first edition of the guide, which listed activities for grades K-8, was composed and reviewed by elementary teachers from throughout the state. Over 4,000 copies of the first edition were printed and distributed to elementary schools and teachers in Arizona from 1973 to 1976.

This second edition of The Environmental Guide expands and updates student activities for grades K-12. This edition was field-tested at Mayer School District during the spring of 1977. The cooperation of the Mayer School staff, administration, and Board is greatly appreciated. Their suggestions have been incorporated into the final revision of the guide.

Individual copies of The Arizona Environmental Education Guide are available from the Arizona Department of Education.



Carolyn Warner
Superintendent

ACKNOWLEDGMENTS

The editors wish to express their thanks to members of the Arizona Environmental Education Advisory Council, and to Mr. Carlos Moore, State Department of Education Director of Agricultural Education and Renewable Natural Resources, for his leadership and efforts in this endeavor. We would like to recognize the efforts of Dr. Fred Staley and Mr. Robert Schneider in helping to develop activities for the Guide. To Dr. Jim Hartgraves, we express our appreciation for his help and support in expediting the financial support necessary to publish this Guide, and to Carolyn Warner, Superintendent of Public Instruction, go our thanks for identifying the need and instituting the organization of the Advisory Council.

A special thanks is extended to the American Forest Institute, Inc. for permission to use classroom activities from Project Learning Tree in the Plant section of the guide.

Grateful acknowledgment is hereby made to the following groups of people and organizations:

1. Washington State University and Joe G. Cvancara, Department Head, Agricultural Education, for the extremely useful materials from the Agricultural Education Environmental Series.
2. The dedicated pilot program instructors at Mayer High School and Superintendent Steve Hudson, for their contribution of time and effort in field testing these materials.
3. Broad Spectrum Environmental Education Program, Florida, an ESEA Title III project.

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INTRODUCTION TO THE GUIDE

It is recognized that man must utilize his natural resources. In doing so, man may alter the delicate balance with his environment and often damage it. Therefore, it is imperative that we understand the relationships between man and the environment in order to protect our natural resources.

This guide provides a basis for developing a sound environmental ethic among today's youth.

ORGANIZATION OF THE GUIDE

This guide is divided into seven major sections, each representing one of the following fundamental natural resources: (1) soil, (2) air, (3) water – from which the other resources are formed, (4) vegetation, (5) wildlife – the living resources, (6) minerals – the essential nonrenewable resources, and (7) man. Even though these resources are treated separately, they cannot be studied separately. For example, air and water are necessary to form soil, and water and soil influence air.

Many entities which are often called resources are not treated in this guide since they are a part of the six fundamental ones. Examples are: forests, parks, ranges, watersheds, natural beauty, wilderness, recreation, aesthetics, and open space.

Within each of the seven major sections there are three subsections which provide the following information:

I. Background Information (white pages)

- A. Introduction
- B. Concepts
- C. Understandings
- D. Vocabulary

II. Suggestions and Activities (colored pages)

Activities are further subdivided into curriculum areas: fine arts, language arts, mathematics, social science, science, vocational, etc. Grade level usage is also suggested.

III. Additional Resources (white pages)

- A. Bibliography
- B. Other Resources

HOW TO USE THE GUIDE

First, it should be emphasized that this guide does not represent a total environmental education curriculum but a resource of information, suggestions, and activities for supplementing your existing curriculum. As a resource this guide might be used in one of three ways:

1. To help you make existing curriculum areas more attractive and interesting to your students.
2. To help you teach an understanding or concept dealing with the interrelationships between man, the resources, and the total environment.

3. To enable you to insert a lesson or activity on one of the resources into your regular curriculum.

Once you're ready to try one of the above approaches, the following may be one good way to get the most from the guide:

1. Look into the "Suggestions and Activities" section (colored paper) and find your curriculum area and grade level (Primary, Intermediate, Junior High, and High School). Find an activity that could spice up your lesson plan.
2. For most sections you will find an activity concept code (e.g., Concept 1A, 2C).
3. Turn to the basic concepts in the "Background Information" section (white pages) which precedes the activities section. Read Basic Concept No. 1 and paragraphs A, C, and F. These short, nontechnical and, hopefully, very readable and informative paragraphs contain the conservation lesson we hope you will incorporate into your regular lesson plan.

CONCEPTS AND UNDERSTANDINGS

The *basic concepts* in this guide relate to the biological and physical interactions within the system of which man is a part. The concepts represent a sound basis for developing your own environmental education program. You also may find some parallel in these concepts and those you use in your own curriculum. If so, you're already on the way to supplementing your curriculum with concepts of environmental education.

The *understandings* help clarify the important elements of each concept. You should select activities that emphasize the understanding that you are trying to "get across" to students.

ADDITIONAL SUGGESTIONS

1. This is a teacher's guide, your guide.
2. We hope you will adapt these materials to fit your needs. Designations of grade level and curriculum areas need not be considered permanent. Activities can easily be modified in most cases to suit other grade levels and curriculum areas.
3. In addition to emphasizing environmental concepts, most of the activities stimulate students to use learning processes. You should encourage students to become personally involved in creating questions of their own to answer; to seek ways of solving the problems they encounter or are investigating; in short, in using such processes as: observing, classifying, measuring, predicting, inferring, communicating, formulating hypotheses, experimenting, evaluating, and interpreting data.

THIS IS YOUR GUIDE CHANGE, ADAPT TO MEET YOUR NEEDS

Editors:

Thomas G. Kennedy, Ph.D.
William R. Hernbrode

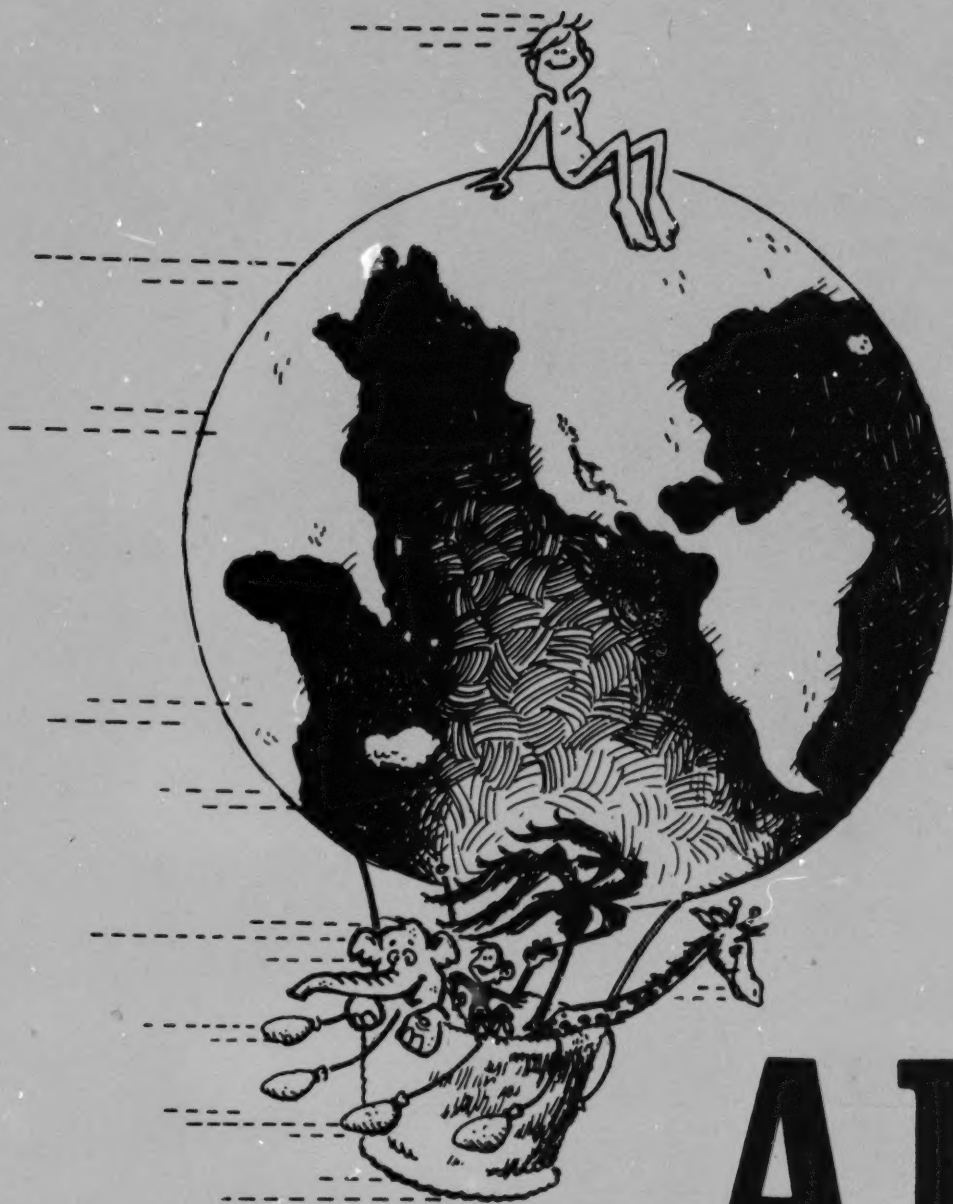
GENERAL

Do not allow attention to always be focused on the thought "pollution." Rather, encourage understanding of natural resources, natural processes, and the problems created in the use and misuse of man's heritage. These problems and conditions come under the general heading of "pollution." If we are "hung up" on problems and conditions that seem to have no solution, we panic. But, if we have deeper understanding of what caused it, why it occurs, and the influence of man, we can see rays, many times broad rays, of hope that at least some problems can be solved. Man's corrective actions and processes, and nature's cleansing powers may well be enough to reverse some of the present trends. Only knowledge and support of such actions can bring them into being.

To develop the necessary understanding and basic knowledge, we must study recorded information, have direct contact with natural resources and natural processes, and have opportunities to individually experience accurate accounts of actual conditions. It is not enough to simply skim over or be satisfied with scattered observations of facts, often incomplete and unrelated, one to the other. To equip individuals with basic knowledge so that they can intelligently understand and support actions that will solve problems is the challenge and the call of educators.

This guide does not attempt to present solutions that, at best, would be incomplete. It does intend to create (1) a basic awareness that "my life depends on natural resources and the products of natural processes," (2) present basic understandings, and (3) encourage further study through activities which enforce and expand the knowledge. The intent is to equip students with basic knowledge and encourage them to continue to study problems until they can intelligently evaluate information available, know how results may be obtained, and actively live the life by participating in programs and activities that do solve problems facing us today.

Solutions may well require that personal values, life-styles, energy demands, and other so-called necessities will have to change. *We cannot expect such changes to be made unless the students understand why.*



AIR

AIR

Introduction:

Air is the mixture of gases that make up our atmosphere. When we speak of air, we are mostly speaking of the troposphere—that air mass closest to the earth's crust.

Air is composed of a number of gases, water vapor, and particulate matter, but it is the oxygen component that makes our planet livable. Without oxygen, no animal life, including man, can exist. This precious oxygen is found only in the first few thousand feet above us.

Natural processes continually recycle and renew important elements of our air. Carbon dioxide is absorbed by plants. The carbon is used for their needs and the oxygen is released into the atmosphere. Plants are the major producers of this most important resource, with oceanic plankton the greatest producers of oxygen. Atmospheric nitrogen is gathered from the air by certain bacteria, which transform it into nitrate compounds which plants can assimilate and use. Plant decomposition releases the nitrogen back into the atmosphere. Temperature, precipitation, and other factors influence the rate of renewal and recycling of atmospheric elements.

Air, as we have seen, is a renewable resource and is essential to all living things. Each plant and animal requires specific quantities of air and uses particular elements of that air in its own way. But air can be contaminated by concentrations of its own elements, such as carbon dioxide, and by other natural or manmade materials.

Some air pollution is natural, as when a hot, dry wind blows across a droughty plain. At that time dust becomes a pollutant. Each of us is a source of pollution, varying with time and place and activity. Industry is a major source of air pollution and towns and cities contribute to the deterioration of air quality. Agriculture produces certain contaminants, and our systems of transportation (cars, trucks, aircraft, ships, and trains) are the greatest single source of air pollution in today's world.

Air movement periodically alleviates air pollution. Such air movement can be small, local systems or planetary movements which encompass continents and oceans.

There is more sunshine over the equator than over polar regions, and the earth is warmer at the equator. Warm air, rising from the warm earth, allows cooler air to flow in under it from cooler, more northerly areas. This movement is called planetary circulation.

The rotation of the earth disturbs these basic patterns and breaks the air masses into areas of high and low pressure. Our air circulation is due to air movement around these high and low pressure areas.

Arizona's major weather patterns are storms from the Pacific Northwest in winter and from the southeast in summer. These are the storms that bring our annual moisture. The northern part of Arizona gets most of its annual rainfall in the winter months; the southern parts of the State receive their moisture during the summer. Areas of the south-central part of the State really have a two-season rainfall, receiving almost equal amounts from the north in winter and from the south in summer. Plants in this area of the Sonoran desert have made special adaptation to this pattern.

But perhaps the most active weather we experience is the daily flow of air. Cool air flows downward from the mountain tops at night, settling in the valleys below. It flows back upward as the morning sun warms the mountains.

This cooler air, lying in the valley bottoms, traps pollutants which may have been emitted into it. As the surrounding mountains warm in the morning sun, the air over the mountains warms, and rises. This uplift pulls the cooler air up from the valleys and disperses the blanket of pollution.

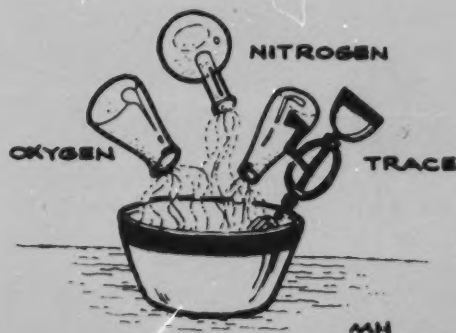
Our air pollution can be reduced and controlled to within acceptable levels. It is important to us all that this be done. The economic losses to air pollution are staggering, with the greatest costs in the area of human health. Air pollution is also detrimental to our crops; certain pollutants have corrosive effects upon metal; others, combined with water, produce acids which destroy historic buildings and statues. Such things affect our lives in many ways, as well as interrupting natural processes. So it becomes important that we, as individuals, begin to consider our own actions. What are we doing which creates pollution? What can we do to reduce our own pollution? That is the first step, but individuals cannot control all pollution sources; these must then become a matter for local, state, and federal governments. We must make sure that our governments are aware of the problems and that we require action to be taken. Only then can the quality of our air improve and the quality of our lives achieve new dimensions.

BASIC CONCEPT NO. 1 – Air is a mixture of gases which make up the atmosphere of our planet earth.

Understandings:

A. Air is a mixture of invisible gases.

Nitrogen comprises about 78 percent of dry air by volume, while oxygen adds about 21 percent. The other one percent of air is composed of small amounts of other gases. The ratio of gases vary according to elevation because of the effects of gravity on the varying specific weights of the gases. Yuma and Flagstaff would have different ratios of each gas because of the altitude difference between the two locations. Although particles of water and dust are present in air, they are not a part of air. The approximate proportions are:



oxygen	21%
nitrogen	78%
carbon dioxide	small amount
hydrogen	small amount
helium	minute trace
neon	minute trace
xenon	minute trace
krypton	minute trace

B. Natural processes affect air.

1. *The Carbon Dioxide Cycle:* Animals, while converting food into energy, consume oxygen and release carbon dioxide. Plants restore or maintain a balance by using carbon dioxide as a raw material for food production and by releasing oxygen as a by-product. This balancing action can be observed in a sealed aquarium or terrarium (see activity section).
2. *The Nitrogen Cycle:* Nitrogen-fixing bacteria, found on the roots of certain plants, remove nitrogen from the atmosphere. This free nitrogen is converted into nitrogen compounds vital to plant growth. When plants are eaten and processed through the digestive system of the plant eater, his wastes return some nitrogen to the air. When plants die, their remains also decay and return nitrogen to the air.

C. The "Greenhouse" effect.

Increases in carbon dioxide, often combined with moist air, trap radiation (heat) near the earth's surface, thus increasing the earth's atmospheric temperature. This creates conditions similar to a greenhouse, where the inside temperature is warmer than the outside—thus the name.

D. Atmospheric circulation and precipitation.

Planetary circulation is the name given to the movement of the air within the entire atmosphere. This type of circulation is due to the air movement around areas of high and low pressure. Planetary circulation is caused by the greater heat received at the equator than at the poles. Without rotation of the earth, the pattern of air circulation would be a rather simple one—warmer air circulating toward the poles, cooling as it moves. Since the earth rotates, we have a complicated weather pattern. Here in Arizona our air is governed to a great extent by the general weather patterns of the northern hemisphere.

As the great land mass of the North American continent cools during the fall and winter months, the storm tracks flowing off the North Pacific Ocean are forced further and further south until they eventually sweep through Arizona. The high plateau country and mountains of northern Arizona are most affected by these wintertime storm fronts. It is then that they receive most of their moisture.

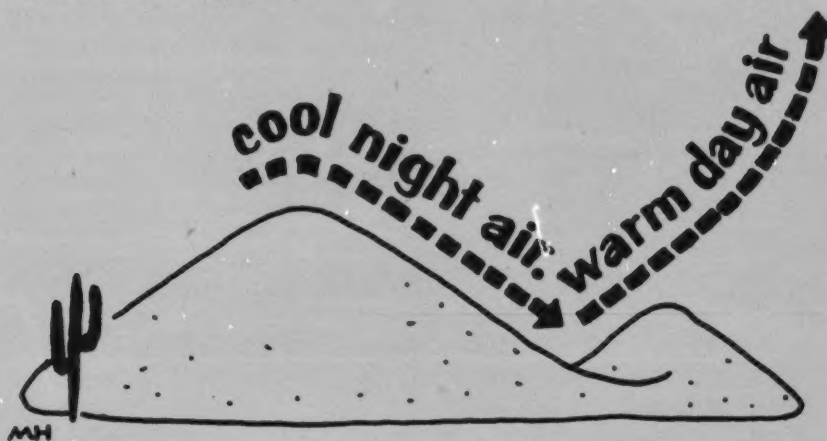
During the summer months, the general circulation in Arizona is governed by what is commonly called the "thermal trough." This is an elongated low pressure area caused by intense solar heating of the desert areas. This stretches from old Mexico through southwestern Arizona and into mid-California. The circulation of air around the thermal trough is from southeast to northwest over Arizona. Moist air from the Gulf of Mexico is usually picked up in this circulation and carried across the State.

The wind patterns over Arizona can be attributed to a great extent to the seasonal weather patterns. The "driving" winds during the winter months are generally from the west and associated with storm-front activity flowing off the North Pacific Ocean. The "driving" winds during the summer months flow from the southeast toward the northwest and are associated with the circulation of air around the "thermal trough." The winds during the rest of the months are in transition between the summertime and wintertime patterns.

Even more important than the "driving" winds in Arizona are the daily drainage and up-valley winds. It has been said that the surface air over Arizona breathes. It flows down each little valley during the nighttime hours and flows up the valleys during the afternoon.

The nearly clear skies and dry air over Arizona allows nighttime radiation of heat from the earth's surface, cooling the surface layer of air with drainage of this air down the valleys much as water might flow. The cold air builds up in the middle of the valleys as a surface temperature inversion, trapping any pollutants which might be emitted into it.

When the sun rises, rapid heating of the earth's surface takes place, particularly on the east and southeastern slopes of the hills and mountains which are perpendicular to the sun's rays. The surface layer of air is warmed over the hills where any surface temperature inversion would be very thin. The air soon becomes buoyant enough so that circulation is established, drawing in air from the valley to replace that which is rising. The daytime cycle of the "valley" wind is then established with the surface air flowing up the valley slopes toward the hill surfaces where the most intense solar heating is taking place. The "hot spots" shift as the solar angle shifts. The surface wind shifts direction accordingly.



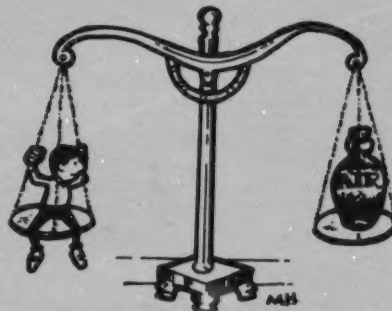
Arizona Valleys "Breathe".

BASIC CONCEPT NO. 2 – Air, one of the basic renewable resources, is essential to all life.

Understandings:

- A. All living things require air for respiration.

Plants and animals require either oxygen or carbon dioxide, both components of air, for respiration. Photosynthesis utilizes oxygen from the air and sunlight to produce plant foods. Man and other animals take oxygen from the air and combine this with blood to feed body cells. Without this nourishment all life processes would end.



B. Air is essential for many of man's activities.

Industrial products are necessary to man's present life style. He depends upon the burning of wood, coal, gas, and oil for the production of energy to run the wheels of industry. All burning processes require oxygen.

One alternative to such methods of energy production is the power created by moving air. Large areas of the United States, the Great Plains, the northeast, and coastal sections have sufficient wind for energy production.



C. Many components of air are renewable.

Through natural processes, such as the carbon, nitrogen, and oxygen cycles, elements of air are renewed. Temperature, wind patterns, and the ratio of plants to animals—all affect the renewal time. Rain serves as a cleansing agent, removing particulate matter from the air in a seasonal regeneration.

BASIC CONCEPT NO. 3 – There are many sources of pollution.

Understandings:

A. Some air pollution is natural.

What is pollution? Too much of anything is pollution. When the normal composition of the gases that form air have been thrown out of balance, such as by an increase of

carbon dioxide, we say that the air is polluted. Any addition of foreign or exotic materials, whatever their form, becomes pollution.

Some of this pollution is from natural causes. When the volcano Krakatoa erupted in 1883, it spewed dust and ash miles into the air. These pollutants were observable in the vivid sunsets for months afterward as the dust and ashes circled the earth.

Saharan dust has been recorded on the east coast of North America; this, too, was a natural pollutant.

B. Individuals are sources of pollution.

Each of us is a polluter. Unthinking, we jump into our car for a one-block trip to the store; we only worry about how well our engine is tuned when it sputters and quits—and unnecessary pollutants are added to the air.

We leave doors and windows open in hot weather, and our refrigeration works overtime. We find clothes dryers more acceptable than drying clothes in the sun and air, and the coal and oil burning power plants work overtime.

These are only a few of the ways that we, as individuals, become contributors to the pollution of our air. How many ways can you think of that you have contributed to air pollution just today?

C. Industries are a major source of pollution.

Industrial air pollution has been brought about largely by the burning of fossil fuels, by the smelting of ore, and by various industrial processes. Industrial air pollutants include: carbon monoxide, sulphur oxides, nitrogen oxides, hydrocarbons, various types of particulate matter, and others.



SUMMARY OF NATIONWIDE EMISSION ESTIMATES, 1970
(10⁶ tons/year)

Source Category	SO _x	Part.	CO	HC	NO _x	
Transportation	1.0	0.7	111.3	19.5	11.7	
Fuel combustion in stationary sources	26.5	6.8	0.8	0.6	10.0	
Industrial process losses	6.0	13.3	11.4	5.5	0.2	
Solid waste disposal	0.1	1.4	7.2	2.0	0.4	
Agricultural burning	Nega	2.4	13.8	2.8	0.3	
Miscellaneous	0.3	1.5	4.5	4.5	0.2	
Total	33.9	26.1	149.0	34.9	22.8	266.7

^aNegligible (less than 0.05 x 10⁶ tons/year).

Source: ERA Nationwide Air Pollutant Emission Trends—January, 1973.

Almost 58 billion tons of these industrial pollutants are being distributed into the air (nationwide) in a given year. Several examples of industries and an estimate of the amount of pollution of each are:

INDUSTRY	Billions of Tons of Air Pollutants
Iron-Steel and Other Metals, Mills	
Smelters	11.9
Petroleum Refining	8.4
Burning of Coke	4.4
Iron Foundries	7.4
Kraft and Pulp Paper Mills	6.6
Cement Manufacturing	1.7
Grain Mills and Handling	2.2
Phosphate Fertilizer Plants	0.6
Total	43.2

The totals continue to grow as industrial activity increases.

D. Agricultural practices cause air pollution.

Each year the equivalent of 30,000 acres of top soil enters the air and becomes a pollutant. Some sources of this pollutant are: fallow land, plowing, and the harvesting of certain crops. The burning of stubble fields adds smoke and particulate material in the form of ash to the air. Hay, ensilage, and grain elevators produce considerable amounts of vegetable dust particulates.

Since most agricultural activities occur in rural areas, with sparse populations, fewer people are affected by this pollution.

E. Transportation is the greatest single source of air pollution.

The Environmental Protection Agency lists the air pollution caused by transportation in 1971 as 143.9 million tons. This means that our transportation systems contribute almost one-half of all air pollutants. The breakdown includes: 111.0 million tons of carbon dioxide, 19.5 million tons of hydrocarbons, 11.7 million tons of oxides of nitrogen, 1 million tons of sulphur oxides, and 0.7 million tons of particulates.



The automobile, burning one-third of the nation's petroleum supply, is the largest source of transportation pollution. Additional size and weight, optional equipment, poor engine condition, and bad driving habits by the operator multiply the pollution caused by the automobile. Lighter, smaller, simpler cars—with well-tuned engines and better drivers—can substantially reduce the auto's pollution.

F. Urban areas are usually subject to heavier air pollution than are suburban and rural communities.

It is estimated that there will be 320 million people in the United States by the year 2000. Three million of these will live in Arizona. Eighty-five percent of these people will live and work in metropolitan areas. Such concentrations of people bring concentrations of automobiles, industry, and the generation of more energy. With these come more pollution.

BASIC CONCEPT NO. 4 – Air pollution is important to us all.

Understandings:

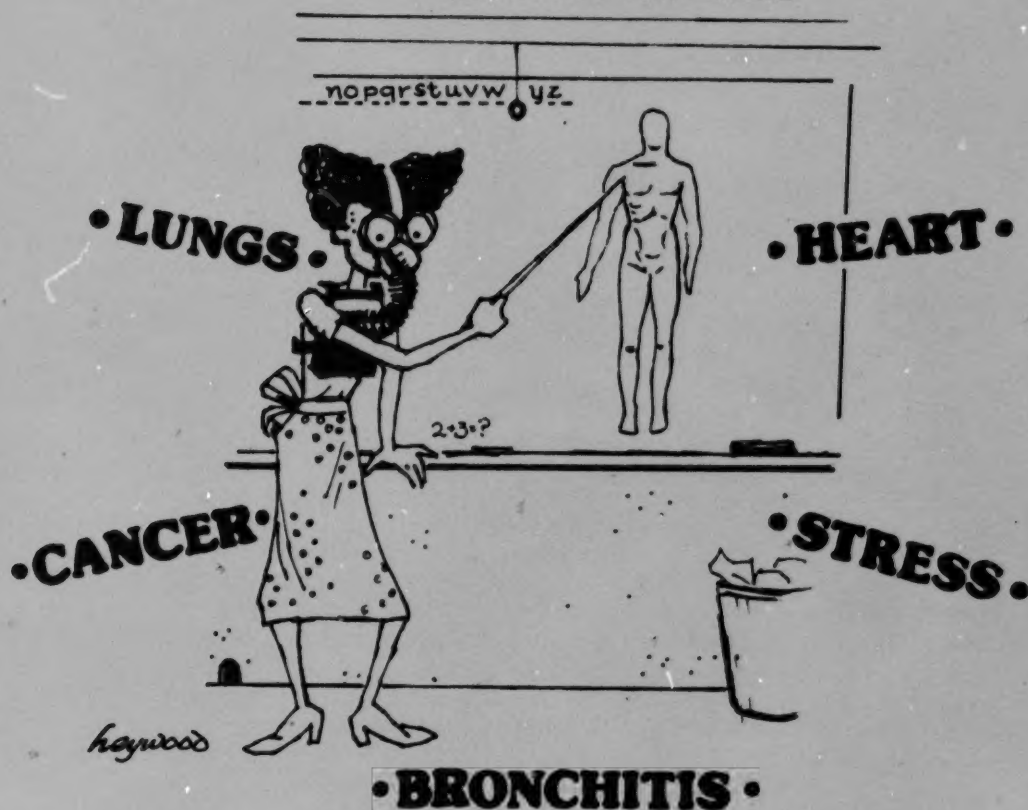
A. The control of pollutants is economically valuable to us.

Damage to human health is the most costly effect of air pollution. Typically, man breathes in 30 pounds of air a day. Scientists are convinced that air pollution is a real contributing factor to three major types of disease and causes of death—heart disease,

lung disease, and cancer. There has been an alarming increase of chronic diseases such as emphysema, chronic bronchitis, and lung cancer.

We still know very little about the effects of air pollution upon our health. What is the individual ability to withstand biological stress? What is the effect of combining one pollutant with another? We know that the burning of coal produces sulphur dioxide and that sulphur dioxide produces injury to the respiratory system. In 1976 the EPA published a study on the effects of sulphur dioxide. The study showed excessive

• EMPHYSEMA •



numbers of respiratory problems in communities exposed to levels of 92-95 UG of sulphur dioxide (50 UG = 0.019 parts per million). Some Arizona communities exceed 100 UG of sulphur dioxides. Lead, a cumulative poison, diversely affects the human body causing mental dysfunction, confusion, irritability, bone diseases, and anemia.

Several animal diseases are carried by the air. Eyes, noses, and other parts of the body are irritated and the morbidity and mortality rates of other diseases are increased. A bone disease in cattle (fluorosis) has been found in areas near steel and aluminum mills.

Vegetation is affected by air pollution, although climatic factors, soil type, and irrigation schedules and techniques may vary the amount of damage. The major pollutants which damage plants are smog, ozone, sulphur dioxide, fluorides, ethylene, and particulates. Air pollution affects the farmer and homeowner alike. The reduced yields on crops and visible damage to ornamentals both result in economic losses. While it is still early for Arizona to have the extent of vegetation damage that other areas have, it is easy to predict, with our weather conditions and diversity of crops and our increasing population and industrial growth, that our problem may well get worse. As there is no known remedy for air pollution damage, it is all too true that with this problem an ounce of prevention is worth a pound of cure.

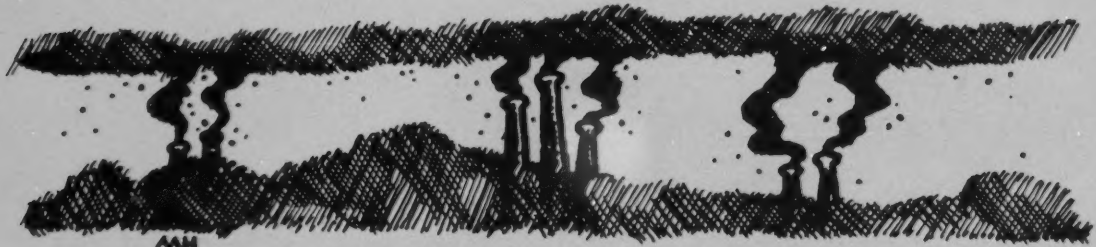
The National Wildlife Federation, in the 1962 Environmental Quality Index, has estimated the economic effects of air pollution:

Air Pollution Cleanup Costs	\$14.2 billion
Air Pollution Damages	<u>\$12.3 billion</u>
Net Cost of Cleaning the Air	\$ 1.9 billion

Although the public is becoming aware of the problem, the PUBLIC must continue to impress upon our government that we want clean air, that we are willing to make the necessary sacrifices to obtain it, as we are the ones whose health is improved! Otherwise, one of the main reasons many people come to Arizona—*clean air*—will no longer exist!

B. Air pollution is visible and is aesthetically objectionable.

One only needs to travel to Los Angeles to view the dull orange-red sun and the depressing grayness of the sky to recognize the aesthetic effects of air pollution on our environment. But one can see the beginnings of the same ugliness here in Phoenix and Tucson. PARPAN (Peroxyacetylnitrate), an oxidant found in smog, produces a bronze-like color on the under surface of leaves. Steel corrodes two to four times faster in urban, industrial areas than in rural areas. The corrosion of buildings and statuary is accelerated when relative humidity is high and sulphur dioxide is present in the air. The two combine to make sulphuric acid. This acid dissolves marble statues, frescoes, and buildings. Many historic buildings and statues in Venice, Athens, and other European cities have been severely damaged. Here in Arizona, there are places where washing can only be put out on the line at certain times—the wet clothing combined with sulphur dioxides in the air produces the same sulphuric acid which eats holes in the clothes.



C. The individual contribution to air pollution control is very important.

We, as individuals, can control air pollution by informing ourselves about the problems involved and the steps needed to overcome these problems. We must be willing to pay the taxes and the higher costs of products to help control air pollution. We must vote to support government programs that help to control air pollution.

We must be willing to "go the extra mile" by keeping our automobiles properly tuned, by using lead-free gas, by car pooling, using mass transit, walking, and biking.

We can reduce our expenditures of energy, and the resultant pollution, by further uses of "living insulation" (trees, shrubs, and vines) which shade and reduce building temperatures and the use of air conditioning.

Look at your home appliances. Which are luxuries? We can reduce our consumption of power by avoiding unnecessary use of all appliances. We can make sure that our heating and cooling systems are properly adjusted and operated; this will consume less polluting fuels.

Perhaps most of all, we must change our ideas, thoughts, and attitudes on what "looks good." We must turn from large cars to small cars; from clothes dryers to solar dryers; from dishwashers to families working together, sharing responsibilities, and learning about each other—in effect, conserving each other. We must utilize solar energy as much as possible to heat our swimming pools, our hot water, and to heat and cool our homes.

In short—we, as individuals, *can* make the difference.

D. Governmental participation at all levels is necessary.

A degree of cooperation exists between federal and state governments and between state and local governments regarding control of air pollution. This is part of the intent of the Clean Air Act of 1970 in which the federal government set certain standards and then mandated that the states enact the necessary laws to reach these standards. The states, in turn, passed legislation forcing various cities and local governments to carry out the necessary action to clean the air. These laws usually include restrictions on open burning, control of auto emissions, and restrictions on the use of certain fuels for producing energy.

For the most part, these interactions have worked well. It is estimated that in 1975 approximately 50 percent of the various air quality control regions established by the federal government were improved or reached the standards set in 1970. There are many problem areas remaining. The cooperation shown must continue. The auto emission control program in Phoenix and Tucson is an example of this cooperation.

SUGGESTIONS AND ACTIVITIES

Mathematics

A. WHAT'S IN THE AIR AND WHERE DID IT COME FROM?

Have students read the two bits of information on "What's in the Air" and "We Need Clean Air" and then make two graphs:

1. One, a bar graph showing the percentage of each type of pollutant in the air, and
2. A second graph showing the sources of pollutants in the atmosphere.

WHAT'S IN THE AIR?¹

Pollutant	Percentage	Description
Carbon monoxide	47%	This is an odorless, colorless gas. It is often found in tunnels, closed garages, and near heavy traffic. It is produced when fuels containing carbon are incompletely burned. Carbon monoxide replaces oxygen in the blood. Large amounts can be deadly. Small amounts cause dizziness, headaches, fatigue, and slowed reactions.
Sulfur dioxides	15%	The burning of coal and oil containing sulfur produces these poisonous gases. They irritate the eyes, nose, and throat. They damage the lungs. They also kill plants, destroy metal, and reduce visibility.
Nitrogen oxides	10%	These gases are produced by burning fuels. They produce a smelly, dark haze that irritates the eyes and nose.
Hydrocarbons	15%	These are produced mostly from unburned fuels during combustion. Large amounts are also produced as tires wear. Hydrocarbons are known to produce cancer. They also react with nitrogen oxides and sunlight to produce smog.
Solid particulates	13%	Dust, smoke, soot, ash—all these are examples of solid matter in the air. They darken the sky and fall out onto many objects. Solid particulates also interfere with normal breathing.

¹Information adapted from *Probing the Natural World*, Volume 3. Intermediate Science Curriculum Study. Morristown, New Jersey: Silver Burdett, 1972.

B. WE NEED CLEAN AIR²

• • Where does air pollution come from?

The dark smoke you see coming from smoke stacks is one kind of air pollution. There are many other kinds you cannot see. Together they make up the serious air pollution that is threatening us.

Every year, over 280 million tons of wastes are released into the air over the United States. This is where they come from:

- 51% from transportation (mainly the internal combustion engines that power our automobiles and planes)
- 15% from burning fuel in furnaces and generators
- 14% from industrial processes
- 4% from burning trash and other solid wastes
- 15% from forest fires and miscellaneous sources

• • What kind of pollutants are there?

Pollutants in the air include particulate matter, sulfur dioxides, carbon monoxide, hydrocarbons, and nitrogen oxides. More information about each pollutant is given on the information card, *What's in the Air?* Sometimes these pollutants combine to form new ones. Nitrogen oxides combine with gaseous hydrocarbons to form smog. Sunlight must be present. Smog is often trapped near the ground and forms a brownish haze over the city.

Air pollution can travel from city to city. It even spreads from one country to another. Some northern European countries have experienced "black snow." It is caused by pollutants that have traveled through the atmosphere. Environmental pollution is really a global concern.

• • How does air pollution hurt us?

It affects your health. Each year, people die from air pollution. It kills babies, old people, and those who have respiratory diseases. Air pollution increases lung diseases. Emphysema, bronchitis, and asthma are on the increase. Air pollution reduces visibility. It can cause both airplane and auto accidents. There are other health dangers that are being studied.

Air pollution costs money. It soils and corrodes buildings. It damages farm crops and forests. It destroys art treasures. The damage in the United States alone is estimated to be \$16 billion each year.

• • What is the government doing about air pollution?

The Federal government began to do research on air pollution in 1955. In 1970, Congress authorized the EPA to set national clean air standards. This is the way the federal government is fighting air pollution:

- EPA set national air standards in 1971. They define how much of each pollutant will be allowed in the air. There are two kinds of standards. Primary standards are those necessary to protect our health. Secondary standards are those necessary to prevent undesirable side effects.

- States and territories must meet national standards. Primary standards must be met by mid 1975. All states must submit plans which show how these standards will be met. If the state fails to do the things in its plan, the EPA can step in and see that they are done.
- EPA has established emission standards for certain industries. These require plants to use the best possible methods to keep pollution to a minimum. They tell the plant exactly what can come out of its stacks.
- EPA has proposed standards for beryllium, mercury, and asbestos. These materials are extremely harmful to human health.
- EPA sets and enforces emission standards for all new cars. Since 1968, all new cars have been required to reduce pollution levels. EPA is doing research and encouraging research on less polluting automobiles.

You can see that we can't cure air pollution just by ordering everybody to stop polluting. If we did that, most of our factories and power plants would have to close down, and we couldn't even drive our cars. But we can clean up our air in the next few years if we are all willing to change our ways of doing things—ways that cause air pollution—just as quickly as we can.

² *Your World, My World*. Washington: Government Printing Office, 1973.

Once the graphs are complete discuss the following:

What is the largest pollutant in the air? What is the largest source of pollution?

Next, have students make a chart to show the effects of each pollutant on the environment; include the way it affects plants, animals, and nonliving things. Make another list of things that can be done to reduce air pollution. Compare this with the action being taken by the Federal Government.

From the lists of measures to reduce air pollution, make a class list of recommendations and send it to your city, county, and state commissioners.

(Concepts 1A, 2, 3)

(Intermediate)

THE AUTO AS AN AIR POLLUTOR

Here are some interesting figures and problems to begin to give students an understanding of the impact autos have on the air:

Apache County had 12,583 vehicles in 1975. In 1969, Apache County had 9,327 vehicles. What is the percentage of increase in vehicles from 1969 to 1975? How many more cars were there in 1975 than in 1969 in Apache County?

The exhausts of automobiles do much to pollute the atmosphere. Autos built in 1965 emit, on the average, 900 parts per million hydrocarbons to pollute the air. Autos built in 1972 emit 180 parts per million of hydrocarbon.

How many autos built in 1972 will it take to pollute the air as much as—

- a. 10 autos built in 1965?
- b. 500 autos built in 1965?

Each year, 11 billion gallons of gasoline evaporate into the atmosphere without ever being used. This is 15 percent of all gasoline sold in the country. Determine the number of gallons of gasoline produced every year in the United States.

If the average cost of gasoline is 60¢ per gallon, how much money is wasted yearly through evaporation of gasoline?

The comfort of auto air conditioning cuts an average of 10 percent in gas mileage. The convenience of an automatic transmission cuts mileage 10 percent also. Each additional 100 horsepower lowers fuel efficiency by 7 percent. Every additional 500 pounds represents a 10 percent decline in gas mileage. If your new car has air conditioning and 200 more horsepower than your present car which gets 20 miles to a gallon, what will your mileage be in your new car? (Concepts 3E, 4A)

(Junior High)

Language Arts

A. AIR VERSE

Ask each student to brainstorm a list of about 10 adjectives which could describe the air. Repeat the exercise using verbs. Arrange words from these lists into a poem in the form of free verse, haiku, or cinquain.

Haiku, originated by the Japanese, consists of three lines of five, seven, and five syllables each. The emphasis is syllabic, not rhyming. Example:

The snow covered tree
Sparkles in the soft moonlight
The wind rushes by

Cinquain is derived from the French and Spanish words for five. This form of poetry also is based on syllables but there are five lines. Each line has a mandatory purpose and number of syllables. These are (1) the title in two syllables, (2) description of the title in four syllables, (3) description of action in six syllables, (4) description of a feeling in eight syllables, and (5) another word for the title in two syllables. Example:

Balloons
Graceful, growing
Climbing among the clouds
Joyfully stalking the sunset
Alive

(Concepts 1A, 1B, 5B) (Intermediate)

B. SHADES OF MEANING

Have the students write a Diamante (a poem shaped in form of a diamond) that demonstrates that words are related through shades of meaning from one extreme to the opposite extreme. For example, "life" and "death."

life
green bright
shining growing blooming
heat motion sun food
fading slowing dimming
brown old
death

The words chosen should match the following pattern of parts of speech:

Noun
Adjective Adjective
participle participle participle
Noun Noun Noun Noun
participle participle participle
Adjective Adjective
Noun

Suggested pairs that relate to air and air pollution might include:

Polluted	—	Fresh
Freedom	—	Regulation
Wilderness	—	Megalopolis
Use	—	Misuse
Materialism	—	Aestheticism
Clear	—	Smoggy
Moving	—	Still

(Concepts 1A, 1B, 5B) (Junior High)

C. ENVIRONMENTAL ADVERTISEMENTS

Ask students to find and bring to class two newspaper or magazine advertisements dealing with some issue related to air, such as auto emissions testing; one advertisement prepared by those conducting the testing, and one prepared by a group opposed to the testing. In class, students should evaluate each advertisement on (1) its emotional appeal, (2) its factual basis, (3) the value system it conveys, (4) the credibility of the arguments stated, (5) the use of propaganda techniques to help communicate the desired message or objective of the advertisement.

After students have written their evaluations, discuss:

1. To which advertisements do you give the most credence? Why?
2. Of two opposing advertisements, do you agree entirely with either? If not, why? If so, do you disagree with all the arguments presented in the other ad?
3. How are the ads similar and how do they differ?
4. What seems to be the purpose behind each group's ad? For example, is it to provide information, to justify a practice, to counter charges?

As a follow up, each student could prepare a scrapbook of the ads and articles, identifying the techniques used to persuade the reader. A written paragraph of explanation could accompany each scrapbook entry discussing its (1) appeal, (2) symbols, (3) effectiveness, (4) purpose, and (5) sponsor.

With your class, talk about how propaganda differs from legitimate communication and if and when propaganda may be legitimate. (Concepts 3A, 3E, 4A, 4D)

(High School)

Fine Arts

A. AIR PERSONIFICATION

Ask your students to personify by demonstrating with large muscle activity the emotions they might feel if they were the air in:

- a gentle breeze
- a violent wind and dust storm
- a gentle rain
- a hard rainstorm with thunder and lightning
- a snowstorm
- a fog
- a smog-filled highway
- the area where someone is smoking

(Concepts 1D, 3B) (Primary)

B. ARTIST AS A RECORDER OF REALITY

Art work, whether that done by paint and brush or the camera, can elicit many different moods and feelings by the viewer. Select several pieces of art or photographs where the air, sky, rain, etc., are depicted. As a class, view these pictures or photographs and discuss with such questions as the following:

1. If you were here in the picture, what might you hear? See? Smell? Feel?
2. What kind of place is this?
3. What colors do you see? How do they make you feel?
4. What could you do if you were there?
5. Where is your favorite place in the picture? *(Concepts 1D, 3B, 4B) (Intermediate)*

Science

A. WHAT'S IN AIR?

This activity could be started with a riddle:

Sometimes it is full of rain,
Sometimes it is full of snow,
Sometimes it is moving
And makes the sailboats go.
It's most important for people
For plants and animals, too.
It's right here in our school room,
And all around you.
What is it?

(Air)

Air does contain many things other than rain and snow, however. The following activities provide students an opportunity to gain first-hand experiences with the ingredients of air:

1. *Air Contains Oxygen.*

OBJECTS

2 test tubes
1 jar
clean steel wool
water
air



EVENTS

Push the steel wool up into the end of one of the test tubes.
Put some water in the jar.
Put the test tubes upside down in the jar.
Mark the water level on the test tubes.

CONDITIONS

There is about the same amount of air in the two tubes at the beginning.

OBSERVATIONS

The steel wool turns rusty after a few days.
The water level goes up in the tube with the steel wool.
The amount of air in the tube with the steel wool gets smaller.
There is a new substance formed in the tube with the steel wool. It is called rust, or *iron oxide*.

Here is some information:

Air is made up of many gases. Two of the most important gases are nitrogen (N) and oxygen (O). Air also contains small pieces of dust and very small drops of water called water vapor.

When the oxygen in the air joins with another substance, a new material is formed. Here are some examples:

Lead	+ Oxygen	= Lead Oxide
Carbon	+ Oxygen	= Carbon Dioxide or Carbon Monoxide
Iron	+ Oxygen	= Iron Oxide

Thus, the oxygen in the air combined with the iron in the steel wool forming iron oxide. When something like this happens we say that a chemical change has taken place.

- a. From your data, estimate what percentage of air is oxygen.
- b. How long did you leave them? Did you *control* for time?
- c. Does changing the objects change the conditions?
- d. Does changing the objects change the events?
- e. Is there any sign of a new substance being formed in any of the tubes?
- f. What else is in air besides oxygen, nitrogen, and water vapor?

When we breathe, air goes into our lungs. The oxygen from the air goes into our blood. When we breathe out, we send out a substance called carbon dioxide. Our bodies are the place where this chemical change takes place.

- g. If we breathe in oxygen and breathe out carbon dioxide, what substance is being oxidized inside our bodies?

Controlled Experiments.

Notice that we used the same size test tubes in the last experiment. We also used the same jar and the same amount of water. However, we put steel wool in one tube but not in the other. The tube without steel wool is called a control. Thus, this kind of experiment is called a *controlled experiment*.

Now, when something changed in the one tube and not in the other we can be pretty sure what caused that change. It must be the steel wool.

Try five or six other materials, such as paper, aluminum foil, silk, plastic, or some iron wire. Which form a new substance (oxide)? Which don't? Make sure you do controlled experiments.



2. Air Contains Carbon Dioxide.

Here is a test for carbon dioxide. Get some lime water. (It can be purchased at a drug store.) or you can get lime water tablets and dissolve them in water. Many chemistry sets contain calcium oxide. This makes lime water when dissolved in water.

Once you have the lime water, blow air from your lungs through a straw into the lime water.



Does it turn milky? This is one way to test for carbon dioxide.

This is another chemical change. The carbon dioxide mixes with the lime water and a new substance called calcium carbonate forms.

Look at the label on a bottle of soda pop. It says that it contains carbon dioxide. How could you prove it? When sugar and yeast are mixed in water, carbon dioxide is formed. How could you prove it? Baking soda mixed with vinegar is supposed to make carbon dioxide.



- a. How could you show that soda pop really does contain carbon dioxide?
- b. What equipment could you use?
- c. How would you set up the equipment?
- d. Did you get any carbon dioxide?
- e. Did you show your test to someone else?
- f. Did you explain it to someone else?

Now place some lime water in a cup or jar and put the jar in fresh air for a few hours. Watch what happens. Is there evidence there was carbon dioxide in the air?

3. *Air Contains Water Vapor.*

Get a tin can which has had the top removed smoothly. Remove the label and scrub it with steel wool until it is bright and shiny. Fill it half full of cold water.

Add two or three ice cubes. Soon droplets of water will form on its sides. When warm air meets the cold sides of the can, the water vapor in the air changes back into droplets of water.

4. *Air Contains Dust.*

Pull down the shades of the schoolroom, switch off lights, and turn on a flashlight or a slide projector light. Little specks of dust will be dancing in the beam of light. (You can often observe dust particles in a ray of sunlight coming through the window as well.)

For additional activities about the pollutants that are also in the air see the section on "Measuring Air Pollution." (*Concepts 1A, 1B*) (Intermediate)

B. IS THERE A FUNGUS AMONG US?

Not all air pollutants are man made. One natural air contaminant is that brought by invisible fungus spores. Mold is a form of fungus. The following activity demonstrates the fact that spores are in the air.

Have students slightly moisten a piece of bread and carry it around the room for about an hour. Then place it in a jar with a lid and keep it in a warm place. Keep records of observations of the bread for a week or two.

Other students could try similar experiments with other items such as fruit or hay.

Follow-up discussion could relate to the effects of spore-type pollutants on human health; i.e., allergies, Valley Fever.

Why are we more concerned with man-made pollutants than we are the natural ones? (Some possible answers might be that man-made pollution is increasing. Some man-made pollutants are very dangerous.) (*Concepts 3A, 4A*) (Intermediate)

C. SMOG IN A BOTTLE

You can create smog in a bottle as a demonstration by actually creating the conditions under which smog (or a cloud) is formed.

Directions:

Press a quart (or larger) milk bottle to your lips and blow hard (thus increasing the air pressure and the temperature in the bottle). Suddenly release your mouth (sudden change in air pressure from high to low causing cooling). What happens? What is observed? (Nothing should happen at this point.)

Add a little water to the jar and shake up the jar (this is like increasing the relative humidity in the air). Blow into jar and release again. What happens? (Nothing should happen, yet, but one more ingredient will do the job.)

What else might be needed besides moisture and a pressure change to cause cooling to create smog or a cloud?

Now put a smoldering piece of cloth or wick or match into the jar (smoke of some sort) and again blow to build up pressure and release. What happens? (You should now have smog or a cloud in the bottle.)

What did the smoke do? (Water droplets need to gather together on and around something—this something can be smoke, soot, dust, dirt, etc.)

How is this process like the formation of smog or a cloud in nature? (Warm air from increased pressure gets saturated with moisture and dust particles, then cooling occurs and cool air cannot hold as much moisture, thus causing condensation. In smog, warm ground air is trapped below cooler air in the presence of particulate matter produced from burning processes. As the cooler air cools or replaces the warmer air smog is created. (*Concept 1D*) (Intermediate)

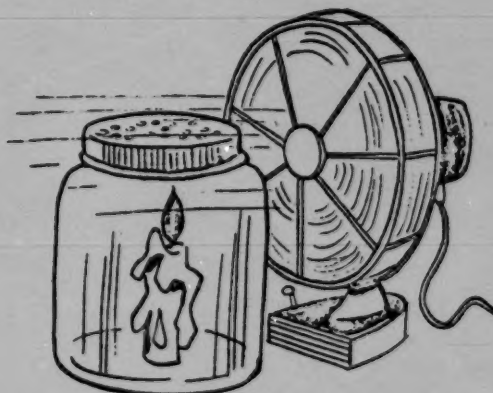
D. SMOKE IN THE AIR

Put a candle in a one-pint Mason jar. Punch small holes in the cover. Now light the candle and put the cover on. Place the jar in a corner of the room which has very little air movement. Don't touch it for 30 minutes.



a. Predict what will happen in the jar.

Put a candle in another jar the same size. Punch small holes in the cover. Now light the candle and put the cover on. Place the jar on a table. Now use an electric fan to blow air over the top of the jar for 30 minutes.



- b. Predict what will happen in the jar.
- c. Predict which jar will have the most smoke in it?
- d. Which jar will be dirtier?
- e. Will both jars look "dirty" after 30 minutes?
- f. Which candle will burn the fastest?
- g. Why did you make the predictions you did?
- h. Were all your predictions right?
- i. Think of a hypothesis that explains what you have observed.

E. OXYGEN-CARBON DIOXIDE EXCHANGE

There are certain conditions that will cause the amounts of oxygen and carbon dioxide to increase or decrease in the air. After examining the following chart students should begin to realize why the amount of carbon dioxide is increasing:

Burning carbon fuels for energy uses up oxygen and adds a large amount of CO_2 to the air.

Rain washes CO_2 from the air to form carbonates (CO_3), which are carried to the oceans.

Plants use CO_2 in the making of food (called photosynthesis); they give off oxygen in this same process.

Volcanoes and hot springs add CO_2 and other gases to the air.

Plants and animals give off CO_2 due to the burning of food (called respiration) and decay.

Large amounts of CO_2 are added to and taken from the air over oceans. This is called diffusion.

Farming releases CO_2 produced by soil organisms. Farm plants use less CO_2 than the forests they replace.

Ocean animals and plants release CO_2 through respiration and decay. Plants use this CO_2 for photosynthesis and release oxygen.

Dead plants and animals that are covered may gradually become coal or oil.

Carbonates (CO_3) sink to the bottom of the ocean, forming layers of limestone which store CO_2 .

After reading the chart, have students make a list of all the activities mentioned that reduce the amount of carbon dioxide in the air. Then make a list of all the activities that add carbon dioxide to the air.

Discuss: Why is the amount of carbon dioxide in the air increasing? What effect will an increase in the amount of carbon dioxide have on the atmosphere? What effect will it have on plants? On animals?

As a follow up, have students make a drawing to show how the things they listed above fit into the oxygen-carbon dioxide cycle. Use arrows to show how the gas that one thing produces is used by another. Show why a balance is important.

(Concepts 1B, 2C)

(Intermediate)

F. MEASURING AIR POLLUTION

Although it is difficult to collect and measure many of the types of air pollution, there are some relatively simple processes students can do to collect and measure some forms of particulate pollution. Students can use any of these approaches in trying to answer such questions as:

1. Where can the most air pollution be found in our neighborhood?
2. What kinds of particulate pollution do we have?
3. Who are the polluters in our area?
4. Which kind of car gives off the most pollution?
5. Is there more air pollution close to the ground or higher off the ground?
6. Is there more air pollution close to a highway or road or 10 feet away, 20 feet away, etc.?

Method 1:

Get a bucket and clean it out carefully. After you think it is clean, wipe it out with a clean white rag. If the rag comes out white, you know you have a clean bucket.

Put this rag in a plastic bag, label it and save.

Put the bucket outside someplace where it won't get knocked over. After a set number of days bring it into the room. Clean with a white rag the same size and color as the one you saved in the bag.

Now compare the two rags. Where did the dirt on the second rag come from?

For additional experiments you could have several buckets in locations which you want to compare for air pollution. (Concept 3)

(Primary)

Method 2:

Take several white index cards marked in 1-inch squares. Coat each with a very thin covering of petroleum jelly. Anchor the cards to something steady with pinch clothespins and place them in various locations around school or the neighborhood. Leave for at least 24 hours.

Use a hand lens or microscope to count the number of particles in each 1-inch square. (*Concept 3*) (Intermediate)

For younger children you can eliminate the 1-inch square aspect and compare petroleum coated cards from different places in a general way; i.e., which is darker? (Primary)

Method 3:

Put about 6 or 8 inches of water in a bucket. Place this bucket outside where it won't get knocked over. After a set period of time, i.e., 10 days, 30 days, etc., bring the bucket back inside. Boil the water out of it.

Take a second metal bucket with the same amount of clean water and boil it dry.

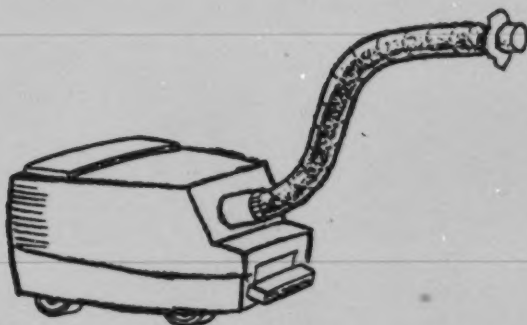
Compare what was left in each bucket. Where did the residue in each bucket come from?

In a month's time, how much pollution fell in an area 10 times as large as the bucket? 100 times as big? How much fell on your school? Your house? On your block? (*Concept 3*) (Intermediate)

Method 4:

Get a tank vacuum cleaner from home. Also, get some fine filter paper. (Filter paper can be bought from a drugstore. You can also use the filter paper that is used to filter coffee.)

Cut a piece of filter paper a little bigger than the end of the hose and place over the hose of the vacuum cleaner. Fold it down.



Now put a rubber band over the filter to hold it in place.

You have just made your own pollutant collector.

Try leaving the cleaner on for 30 minutes in your home or school. Look at the filter.

Put a new filter in. Collect the pollutants outside your school or house for 30 minutes. Compare the filters.

Try collecting the pollutants in different places. Collect at different times during the day in the same place.

Try collecting the exhaust coming from an automobile.

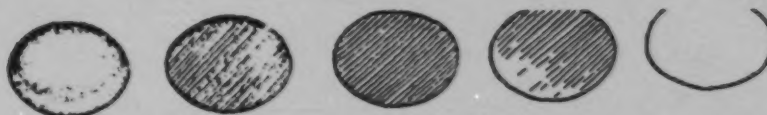


Be sure to stand at the side of the automobile so you don't breathe the carbon monoxide.

Try different cars.

Label and save all your filters. Label and keep track of where and when you collected them.

Group them by putting them in rows from very light (few pollutants) to very dark (many pollutants). (*Concept 3*)



(Intermediate)

Method 5:

Cover two cardboard squares with 6-inch strips of flypaper, sticky side out. Put one square in a box where no air currents can reach it. Place the other squares outdoors.

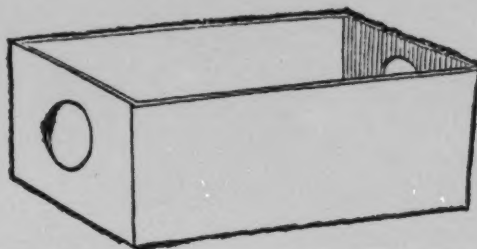
After three days, observe and compare all the squares with a microscope. Keep a record of the weather for a month and every three days compare the square in the box with those outside. Is there a connection with the amount of dust in the air and the weather during the month? (*Concepts 3, 4B*) (Intermediate)

G. PREVENTING AIR POLLUTION

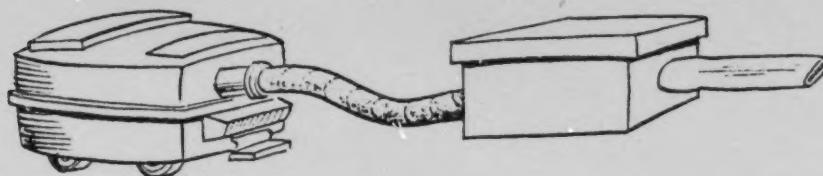
Collecting samples of air pollution is one thing. Preventing pollutants from getting into the air is another. Here are two ways to see if you can control the amount of pollutants in the air.

Method 1:

Make yourself a "bag house." To do this, you will need a shoe box, some rags, a vacuum cleaner, a small piece of screen, and a piece of filter paper.



Cut a hole in both ends of a shoe box. The holes should be the same size as the hose on your vacuum cleaner. Tie a piece of screen over the end of the hose. Place that end of the hose into one end of the box. Tape around the hole to make it as airtight as possible. Place one end of the vacuum cleaner pipe into the other end of the shoe box as shown. Tape around the hole. Fill the box loosely with clean rags. Tape the lid of the shoe box down. Attach the hose to the vacuum. Now turn the vacuum on.



Try collecting the pollutants from an automobile exhaust. After you do this for 30 minutes, open up your box.

- Where are the pollutants?
- How can you get rid of them?
- Did your method of getting rid of them cause a different kind of pollution?

Try it again. This time, put a piece of filter paper over the metal screen. Compare this filter paper with one you did earlier without your "bag house."

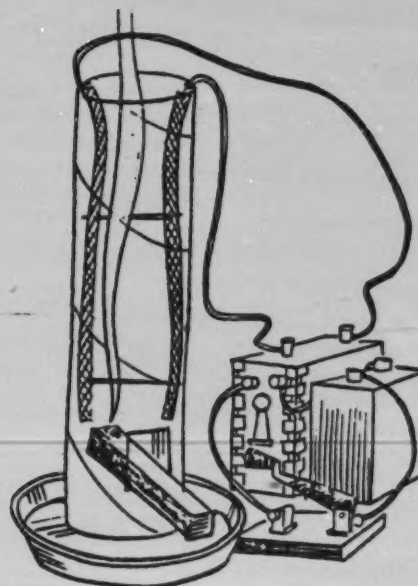
- Is the filter paper cleaner?
- Explain why it is cleaner.
- How did you get rid of the pollutants you collected? Did the method you used cause a different kind of pollution? (Concept 4C) (Intermediate)

Method 2:

To do this experiment, you will need the following things:

- 1 cardboard tube (the kind that comes with paper towels or wax paper)
- 2 strips of copper screen 6 inches long by 1 inch wide
- 6 feet of stranded wire (lamp cord)

- 2 toothpicks
- 1 stick of incense
- 1 spark coil
- 1 knife switch
- 1 6-volt battery
- 1 metal dish



Set up the equipment as shown. The toothpicks are there to prevent the pieces of copper screen from touching each other.

When you have finished setting up your equipment, light the incense. You should be able to see the smoke traveling up through the tube and smell the incense. Now turn on the spark coil. Observe.

- a. What happens when you turn on the coil?
- b. Make a hypothesis about what is going on inside the tube.
- c. Think up ways that this device could be used to prevent pollution.

This device is called a Cottrell precipitator. It was invented by Professor F. G. Cottrell and was a breakthrough in air pollution prevention.

- d. Look up the Cottrell precipitator in an encyclopedia. Write a story about why and how it was invented. (*Concept 4C*) (Junior High)

H. HOW DOES AIR POLLUTION AFFECT PLANTS?

Students can demonstrate their ability to carry out a controlled experiment to design a procedure to answer this question. One possible way to answer the question is with the following procedure:

CAUTION: Many common air pollutants, including sulfur oxides, nitrogen oxides, and carbon monoxide, are poisonous and should not be handled by inexperienced people.

Following the instructions on the seed packet, plant several white petunia seeds in each of six pots containing potting soil or peat moss. After the seedlings are about two inches tall examine the effects of at least two kinds of air pollution on them. Use two plants as controls; then expose two plants to the fumes from burning matches and two plants to the fumes from a burning cigarette lighter.

To produce the two types of pollutants needed for this investigation, place wide-mouthed quart jars over the plant pots. Fill two jars with fumes from two or three burning wooden matches. Let the matches burn while the jars are inverted over them for about a minute. Then tighten a lid on the jars until you are ready to invert them over the petunia plants. Follow a similar procedure to collect two jars of gas from a burning cigarette lighter.

When you have collected the four jars of pollution, making sure that all jars are labeled, place them over the four experimental petunia plants. Place empty jars over the control plants. Leave for 15 minutes.

Repeat this procedure once a week, making sure not to contaminate the control plants. Keep accurate records of your observations of these plants. What differences do you observe in the heights, sizes, colors, and vitality of the plants? What pollutants could you use for other investigations of air pollution on plants? (*Concepts 4A, 4C*)

(Junior High)

I. PLANT LIFE USES CARBON DIOXIDE

Begin by having students bubble exhaled air into a beaker containing lime water until it turns to a milky white solution. From previous experiences students should know the white color is an indication of the presence of carbon dioxide.

To this add some *elodea* and other aquarium plants and place in the sunlight. NOTE: Within the hour, students should see that the carbon dioxide is being absorbed by the green plants in the process of photosynthesis.

Follow-up questions might be:

- a. Why did you bubble exhaled air into the beaker?
- b. What happened when you added the *elodea* to the water? Why?
- c. What happens when more *elodea* is placed in the beaker?
- d. What happens when a greater concentration of carbon dioxide is used?

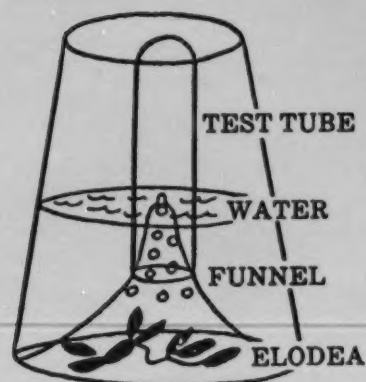
(Junior High)

Plants Produce Oxygen in Photosynthesis

The following demonstration, or experiment, by a group of students can be easily set up to demonstrate that oxygen is added to the air by plants.

Place a few strands of *elodea* under a funnel in a large cylinder of water to which a pinch of bicarbonate of soda has been added. Invert a water-filled test tube over the funnel, being careful not to allow air to enter the test tube. Leave the jar in bright sunlight for a day. NOTE: When gas has collected in the tube, place glowing splint into the tube of gas and note the results.

- a. What has happened?
- b. How could you prove that this is oxygen?



As a follow up to the previous two activities, additional discussion and experiments relating to the following issues can be conducted:

- a. What would happen if some elodea were placed in a very small closed container of water?
- b. What would happen if some elodea and a fish were placed together in a small, closed container of water?
- c. What would happen if a fish were placed in a very small container of water? Why?
- d. Why did the elodea die? Why did the fish die? Why did the elodea and fish live in the third container? (*Concept 2A*) (High School)

J. INVESTIGATING THE OXYGEN CYCLE

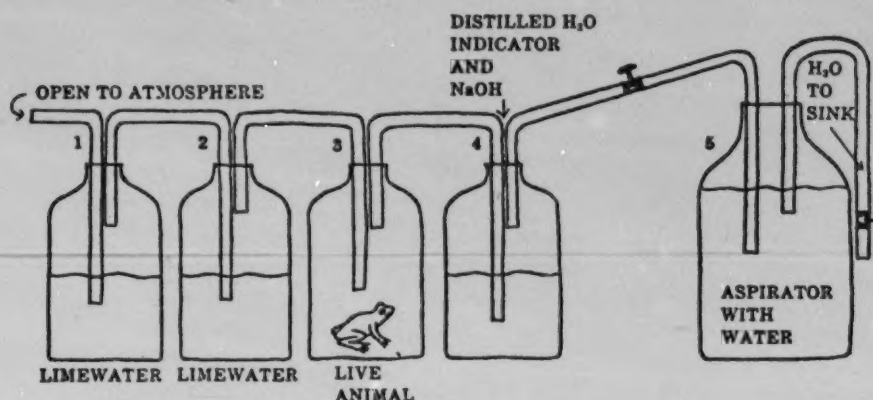
The following activity and experiment can be set up by a group of students to help them understand the function and relationship of plants and animals in the cycling of oxygen and carbon dioxide in the atmosphere:

Set up in the following manner:

- a. In jars 1 and 2 pour lime water to a depth of about 5 cm.
- b. In jar 3 place small live animal, such as mouse or frog.
- c. In jar 4 pour 100 ml. of distilled H_2O and add 5-10 drops of phenol red indicator. Add sodium hydroxide solution, drop by drop, until the solution turns pink. While adding these drops, swirl the solution, making frequent stops to check the color.
- d. Jar 5: Fill large jar with water up to stopper fitted with tubing. Each jar is then airtight. Connect as follows:

Suck on the rubber tubing to start the flow of water from the jar. Adjust the screw clamp so that the flow is steady and moderate. (As the water drains from the large bottle, air will be drawn through the series of jars. The lime water in jars 1 and 2 will absorb the CO_2 from the air entering. In this

way the animal will breathe air lacking CO_2 .) Allow the air to move through the jars for 10 minutes. Observe any color change in the indicator for jar 4. At the end of 10 minutes, remove the animal from jar 3. Detach jar 4 from the set-up and place it against a white background.



Slowly add NaOH solution from a pipette. Carefully and accurately measure in milliliters the amount of NaOH solution required to turn the indicator pink again.

Calculate the amount of CO_2 produced by the animal in the following manner:

Multiply the number of milliliters of NaOH solution by 10. This will give you the number of micromoles of CO_2 produced by the animal in 10 minutes. (1 micromole of CO_2 = 0.000044 grams.)

Developing the Concept

- The carbon dioxide released by the animal is the result of what process? (Respiration)
- What happens to the carbon dioxide released by the animal? (Plants in the process of photosynthesis may absorb it and thereby it would become the basis of organic compounds which are common to all living things and fossils.)
- How do green plants use carbon dioxide? (Photosynthesis)
- What gas is given off by green plants in the presence of light? (Oxygen)
- What happens to the oxygen given off by the green plants? (Some is used by living forms in respiration; some is chemically combined with elements; some is dissolved in water; some is released in the atmosphere. Twenty percent of atmosphere is oxygen.)
- Could this lead to a depletion of our oxygen supply on the planet earth? What has prevented depletion of our oxygen supply on earth? (It is replenished continuously by green plants.)

(Concept 2A)

(High School)

Social Studies

A. WHAT SHOULD WE DO ABOUT OUR CITY'S AIR POLLUTOR? – A Simulation Game

The Problem:

An industry in town is putting out great quantities of black smoke as a result of the burning of its waste products. The town is located in a valley which means the smoke is not blown away easily. A group in town has formed to stop pollution of the air. This group is complaining to the town council about the smoke problem.

The industry says it cannot afford to change its method of waste disposal. Other people in town oppose the control of the smoke because they feel it will discourage industry from moving to their community. They say this would prevent economic development.

The Players:

1. Town Council – This is the town's governing body which will decide whether the smoke pollution will be stopped. The purpose of the other groups is to persuade this council through their representative that their position is correct.
2. Industry Representatives – This group represents the industry which is causing the smoke pollution. They are naturally concerned with their interests and want to keep their profits at a maximum. However, they are interested in public opinion and may respond to public pressure. The group claims that their economic development will be harmed if strong controls on smoke emissions become law.
3. Citizens for Clean Air – This group is determined to solve the smoke pollution problem as soon as possible. Its members believe that a clean environment is more important than a profitable industry in town. The group also believes that the waste product being burned could be put to a valuable use. Most people in this group do not depend on the industry for their jobs.
4. Citizens for Economic Development – This group is composed of businessmen and also people who work for the industry causing the smoke pollution. They are siding with the industrial group since they are concerned with the town's economy. However, this group realizes that environmental quality is important and might seek a slow, gradual solution to the problem so that the industry is not hurt.

Procedures:

Divide the class into the various groups. Each group should meet and discuss what it wants the town council to do about the problem, and what the group thinks is needed to make this a better place to live. The ideas should be based upon some research into the problem, not just personal opinion. Elect a spokesman for each group to present its "case" to the town council when the class meets as a whole again.

The town council should elect one of its members to be in charge of the meeting. After listening to the representatives from the different organizations the town council should come up with a list of priorities—a list of what it is going to act upon first, second, etc. Your class may wish to invite a member of the real town council to meet with you and discuss your ideas.

Conclusions:

What solutions to the smoke problem did the members of your class think were the best?

What is your own opinion about the smoke pollution problem above?

If your class found the smoke pollution problem interesting, you may want to find out if there are groups in your town discussing or working together on a major problem concerning land use, air pollution, noise pollution, or water pollution. Perhaps someone in your family is interested in pollution problems. Also, your local newspaper probably has articles on major problems in your town. (*Concepts 4A, 4D*) (Intermediate)

B. THE "ROT" OF BUILDINGS BY AIR POLLUTION

Check with the state historian to determine when the roof of the capitol was refinished and the cost of this task. How does it look now? What do you think caused this?

When was the Erectheum Temple built? Where else in the world are statues being moved inside to prevent them from deteriorating? What does this mean to you?

Ask parents — long time residents — of your town if the air pollution has increased or decreased in the past five years in your town. Check with the County Health Department for air pollution reading for your town. (*Concept 4B*) (Junior High)

C. THE BURN OF 1973

Read newspaper accounts of the air pollution caused by a prescribed burn on the Fort Apache Indian Reservation the week of November 13, 1973. Talk to people who have lived in the cities affected. Perhaps your school was closed during this period. Discuss how or if this emergency could have been prevented. How can various agencies work together to prevent further occurrences. Everyone talks about "rights." We have responsibilities; when we assume our responsibilities, then we also inherit rights. Supreme Court Justice Oliver Wendell Holmes said, "Your rights cease when they injure the rights of others." Discuss this thought concerning air pollution from any source. (*Concepts 3A, 4B, 4C, 4D*) (Junior High)

Industrial Arts

A. MEASURING AIR MOVEMENTS

The fact that air movements are constantly changing can be seen by watching a wind vane and an anemometer. Here are ways for students to make these instruments and then observe the changes in wind speed and direction.

1. Wind Vane or Weather Vane – Wind Direction

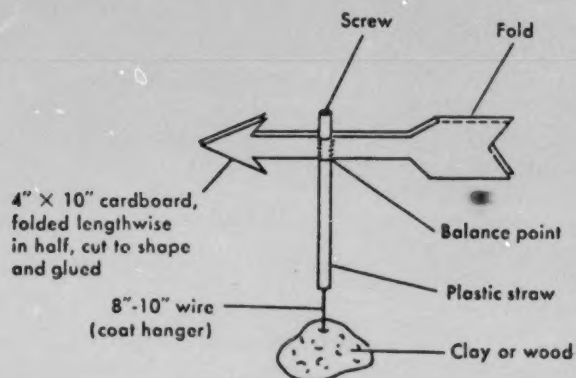
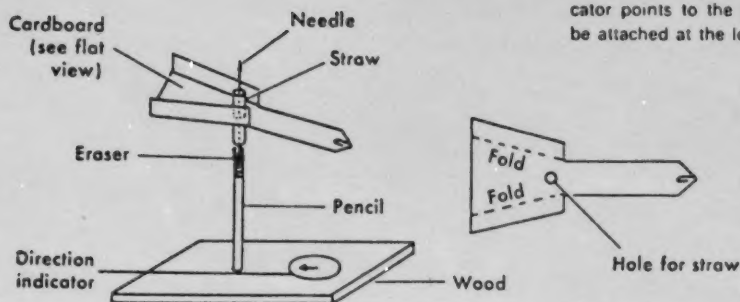


Fig. 3-9. Weather vane. It must move freely and will point to the direction from which the wind is blowing. The instrument must be placed so that the arrow of the direction indicator points to the north, or else a magnetic compass may be attached at the location of the direction indicator.



(Concept 1D) (Intermediate)

2. Anemometer – Wind Speed

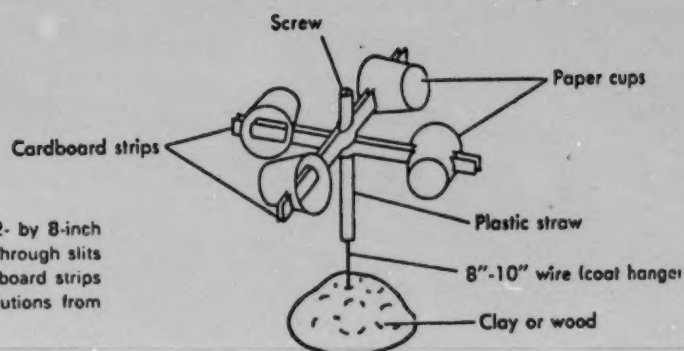


Fig. 3-8. Wind gauge, or anemometer. Fold 2- by 8-inch cardboard in half lengthwise and insert in cups through slits 1 inch from the tops of the cups, with the cardboard strips at right angles. Color one cup and count revolutions from the car window at different speeds to calibrate.

Questions to think about and discuss:

Why is it that the weather isn't exactly the same on the same day, June 30th for example, in succeeding years? The sun is shining at the same angle, rises and sets at the same time, and the rotation of the earth is the same. What is different?

(Part of the answer lies in the fact that the surface of the earth is constantly changing from erosion, earthquakes, and volcanoes, plant communities change, the animals change and they change the environment some.)

Could wind patterns be affected by pollution? This is a possibility because of the effects on temperature; that is:

- The possible rise in temperature because of contaminants in the air which help to hold the heat against the earth, as a cloud cover does.
- A possible lowering of temperature if there was an increase in the carbon dioxide level.
- Local change in temperature near the ocean because of film on the ocean surface, collecting there from air pollution.

It should be pointed out that these are only educated guesses at this time.
(Concept 1D) (Intermediate)

VOCABULARY

atmosphere ('at-mo-sfi(e)r) – The outdoor air. The gaseous layer that surrounds and moves with the geosphere (solid earth).

air pollution – Befouling the air with gases, vapor, dust, or noise. A change in the air, usually caused by man, that reduces the ability to support life and often lowers visibility. Substantial deflection from normal air composition.

aerosol ('ar-e-sol) – Microscopic particle (particulate) that remains suspended in air because of its small size.

ambient air ('am-be-ent) ('a(er) – The outdoor air which surrounds you; about the same meaning as atmosphere.

biosphere ('bi-o-sfi(e)r) – All living things together with their environment; also, as often used, it refers to the atmosphere, water, and land surface where all organisms, including man, live. See ecosystem.

carbon monoxide – Colorless, odorless, very toxic gas produced by incomplete combustion of organic substances, primarily emitted through exhaust of gasoline powered engines.

ecosphere ('e-ko-sfi(e)r) – Layer of earth and troposphere suitable for the existence of life. Atmosphere, biosphere, ecosphere, and troposphere are closely related.

fluorides – Compounds containing fluorine emitted into the air from a number of industrial processes; a cause of vegetation damage.

hydrocarbons – Big family of compounds containing carbon and hydrogen only, in various combinations; found in fossil fuels and contribute to photochemical smog.

inversion – Situation when air next to the earth is trapped by a layer of warmer air above it so that the bottom layer cannot rise.

nitrogen oxides – Gases formed when fossil fuel burns under high temperature and pressure as in an automobile or other internal combustion engine. Contribute to photochemical smog.

oxidant ('a-sed-ent) – (1) Ability of some substances to react in the air and form new substances, and (2) A substance that makes oxygen available for such a chemical reaction.

ozone ('o-zon) – Pungent, colorless, toxic gas, a product of the photochemical process.

particulate – Particle, solid or liquid, such as soot, carbon (lead perhaps), sulfuric acid aerosols, that result usually from the burning of coal, jet fuel, diesel, gasoline, manufacturing and smelter operations.

photochemical process – Chemical changes resulting from action of the sun on some of the pollutants. The products are often called photochemical smog.

sulfur oxides – Smelly, colorless gases, mostly from burning coal and smelter operations. Sometimes they may damage the respiratory tract and have been known to damage vegetation. They may also, with moisture, form some sulfuric acid and sulfuric acid aerosols.

smog – Irritating haze resulting from the photochemical process, mostly by the chemical change of hydrocarbons and nitrogen oxides. Originally, it meant a combination of smoke and fog.

troposphere ('trop-o-sfi(e)r) – Innermost part of the 12-mile air layer surrounding the earth.

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MAN in the ENVIRONMENT

MAN IN THE ENVIRONMENT

Introduction:

Man began as a simple *omnivore*, who gathered fruits, nuts, and seeds; who killed and ate animals smaller than himself—and was then *prey* for the larger *carnivores*. He was an integral part of a functioning *ecosystem*. He was a part of the web of life—of no more importance than a plant, a bird, or a fish. But that was earliest man.

As man developed into an *agriculturist*, he began to have more impact upon his environment than the other animals around him. He disturbed the soil, transported and distributed seeds, and diverted water for irrigation. His impact was still light, but increasing.

Although man appeared on earth well over a million years ago, his populations increased almost imperceptibly until he became a farmer—but the increase began to be noticeable. Even then, human populations amounted to only about a quarter of a billion by the beginning of the Christian era. By 1820 the world contained a full billion—and only 110 years later, in 1930, another billion had been added. Only 30 years later, in 1960, there were three billion people on earth and in 1976 there were four billion. It is predicted that by the year 2000 there will exceed six billion people.

As human populations increased, human needs increased to the same degree. Man needed more plants and animals for food, clothing, shelter, and warmth. And, as he became a tribal or *communal* animal, man began to develop wants as well as needs. When one superior man developed a bow and arrows, or a better stone axehead, other men wanted the same for themselves.

In more modern times, needs have increased faster than populations because a more complex society creates more needs—but man's wants have increased *exponentially*. This formula of increased populations times greater needs, times increasing wants, has put stress upon natural resources. The procedures of harvest and processing of these resources have created additional impacts upon the environment. Man's technology may supply needs, but it also creates wants and these same technological processes can interfere with natural cycles and systems.

Certain parts of our natural environment are irreplaceable. Living resources are renewable; plant and animal resources are renewable—but can be destroyed. And with their destruction comes interference with natural cycles such as the carbon, water, and oxygen cycles. No life on our earth can exist without these systems.

Concentrations of human populations often lead to environmental deterioration. When man lived in family groups he was forced to move from time to time because he had harvested the plant and animal resources to a level where it became difficult to feed himself. But he was also forced to move when the accumulation of his wastes became unbearable.

Modern, metropolitan man brings resources from the far corners of the earth and builds permanent dwellings. He finds it difficult to move—and his wastes have become a major environmental problem. Not only does he have the scraps from his table and his body wastes to dispose of, but quantities of effluent from his technology which becomes increasingly difficult to dispose of. Such materials as radioactive wastes, industrial chemicals, and pesticides or *herbicides* are difficult to dispose of in a safe and proper manner. In some cases the technology for disposal has not yet been developed.

The masses of daily waste—garbage, rubbish, and industrial trash—have become burdensome in quantity. A quality environment can no longer be sustained when these wastes and by-products are dumped into rivers, lakes, and oceans or hidden in land-fill dumps where their leachings create further problems.

Our very complex society promotes conflict between man's needs and wants, and the quality of the environment. Almost anyone living in Arizona must have transportation in order to get along. So, at the present time, an automobile may be classed as a need—yet automobiles are the major contributor to air pollution in urban areas. Other forces, manufacturing and advertising, push to sell more, bigger, and newer cars in order to keep employment up and for the stockholders' invested money to bring reasonable returns. None of these things are wrong—it is important that people can receive a return on their investments, or there would be no money available for medical research, education, or other important social needs. It is important that the factory hums—because hundreds or thousands of people depend upon it for a livelihood. But there are conflicts between the *needs* for transportation, the *desires* for newer and bigger cars, and a livable environment.

Modern man's consumptive practices and patterns are constantly changing. Items, once made of wood, are made from *petrochemical*-based plastics; steel and iron are replaced by aluminum or magnesium; and the volume of materials processed increases exponentially. Newer models are available yearly—with intensive promotion of the idea that "newer is better." We have been called a "throwaway society"—we are certainly a wasteful society—and the rest of the world seeks to emulate our life-styles.

How can we plan for the future availability and use of oil? Should we continue to use petroleum as a source of energy, or, in the long-term best interests of mankind, should we conserve this limited resource for its uses in medicine, agriculture, certain plastics, the lubrication of essential machinery, or other, carefully chosen uses? Can we continue to increase our uses of wood products from limited forests—or should we develop a massive recycling of used materials into the system?

If man is to reduce the drain upon *finite* natural resources and to reduce the environmental impacts, there must be long-range planning to meet, not only the natural resource needs of future generations, but to assure a healthy environment for ourselves as well as the future. Such planning, to be effective, must include not only scientific, but social, understandings, and must proceed toward particular objectives.

Economics alone should not be the criteria for resource use and management. Perhaps some decisions will not be economically sound—we must be willing to pay the differences.

BASIC CONCEPT NO. 1 — Man has acquired the ability to significantly alter the environment.

A. Man may unknowingly upset natural systems and cycles.

Man, by a failure to understand natural systems, and a lack of consideration of his impacts, has upset, or interfered with, natural cycles and systems. Organic sewage, dumped into rivers and lakes, increases phytoplankton and other plant growth. The plants overutilize the dissolved oxygen in the water at the expense of aquatic animal life. The delicate balance of production and use by plants and animals has been destroyed. Bays and estuaries are being affected by chemical pollutants and oil spills.

At this time a chemical pesticide called Kepone is infiltrating the Chesapeake Bay ecosystem and some oysters and fish are contaminated beyond acceptable limits for human consumption. Although very little research has yet been done, it is obvious that tremendous ecological damage has been done to this great bay. Saltwater estuaries and bays are the nurseries for much sea life; if the nursery is destroyed, so are its products—shrimp, clams, oysters, crabs, and other animal life.

A classic example of interference with natural balances here in Arizona was the removal of natural controls, such as mountain lions, coyotes, and wolves from the famous Kaibab deer preserve. This action, combined with heavy livestock grazing and logging, which changed plant communities, created a temporary paradise for mule deer and their population exploded. The resulting numbers of deer were more than the habitat could support. The food supply was decimated, and thousands of deer starved.

Man's use of the automobile has improved his mobility and expanded his horizons, but chemical compounds, released into the atmosphere by his automobiles, have changed the composition of natural air components, and affect plantlife and man himself.

Man must decide if lakes, streams, rivers, and oceans are to become highways of debris, waste products, and filth or providers of pure water. We all need to consider Robinson's injunction to Tristram: "Whether you will or not—you are a king, Tristram, you are one of the time-tested few that leave the world, when they are gone, not the place it was. Mark what you leave."

B. Technology can both create and solve environmental problems.

Demands for copper have depleted the richest ore bodies. But modern technologies have been developed to allow the mining and smelting of ores containing as little as one-half of one-percent copper. The technology has produced machinery capable of gouging out 100 tons of rock in one bite, and trucks, with 12-foot tires, which haul 150 tons and more. This equipment, operating in open-pit mines, makes possible the mining and extraction of these low-value ores.

The application of technology solved the problems of copper production, but created environmental problems. What can be done with the resulting open pits and the man-made mountains of tailings? What can be done with the great Lavender Pit in Bisbee, or those now developing south of Tucson, or the hole that has engulfed the towns of Ray and Sonora?

Super tankers, carrying millions of gallons of crude oil, circle the earth—transporting raw energy from where it is found to where it is needed. We must admire the technology capable of creating these behemoths. Yet, these great ships, created to help man, become a terrible threat to man's environment during violent oceanic storms, or

man's effect on nature.



when errors in judgment cause tankers to run aground or sink. Just during the first few weeks of 1977 a half-dozen such incidents, worldwide, damaged ocean environments. Just one of these spilled seven million gallons of oil over the Georges Bank, perhaps the most important north Atlantic fishery—and threatened the beaches and estuaries of Nantucket Island.

The process of developing detergents, to replace soaps, to keep us cleaner, created negative and unanticipated consequences. City sewage systems and water purification plants were unable to remove the phosphate ion contained in the detergents, and huge, billowing mounds of suds accumulated at treatment plants and downstream from them. The technology for cleaning was positive—but the by-products and results were negative, and the chemical technology had to be redone.

Those same technological skills of modern man which created the heavy equipment and open pits; tankers and oil-spills; detergents and excessive foam, can also be concentrated to solve environmental problems if given local, state, national, and worldwide priorities.

TECHNOLOGY SOLVES PROBLEMS...



"D.D.T..."

KILLS INSECTS...
HELPS PRODUCTION.



& CAUSES PROBLEMS...



C. Certain parts of our natural environment are either difficult or impossible to replace.

Our natural environment is a complex arrangement of interrelated systems, checks, and balances. As with any system, if altered it will assimilate the change, if time permits, or will cease to function.

Toxic fumes from a copper smelter in Copperbasin, Tennessee have killed all plants for miles around. The loss of plants has created extreme soil erosion and water pollution far down the drainage. With no plants, there is no wildlife. Pictures of the area depict a grim and ugly scene. Attempts to revegetate the site have been largely unsuccessful. The toxins are still in the soil and leach out into the surrounding water sources. The entire ecosystem has been destroyed.

San Francisco Bay has been filled in to such an extent that restrictions in water flow occurred. Nutrient cycles were interrupted, limiting and destroying marine plant and animal communities and dependent species. The natural flushing of the bay by its rivers has been greatly reduced by the upstream diversion of river waters to other uses. This also contributed to the decline of marine communities, many of which were the nurseries for species man cherishes for food—such as the Blue crab.

Every major drainage in Arizona was recommended for "*phreatophyte* control"—the removal of all streamside vegetation. The concept was that this would give more water to downstream users. What was not considered was that this would also destroy the major habitats for wildlife in a desert state.

Important agricultural lands along the Pacific coast are being threatened by salt water replacing fresh water in underground sources. Heavy pumping, to irrigate farms, pumped out fresh water faster than it could be replaced. This allowed sea water to *percolate* inland through sandy, rocky, alluvial deposits. Now wells bring up salt water instead of fresh and a major food-producing area is in danger. If you like artichokes you will be sorry to hear that part of this area is called "the Artichoke Capitol of the World." But it also produces many other important foods.

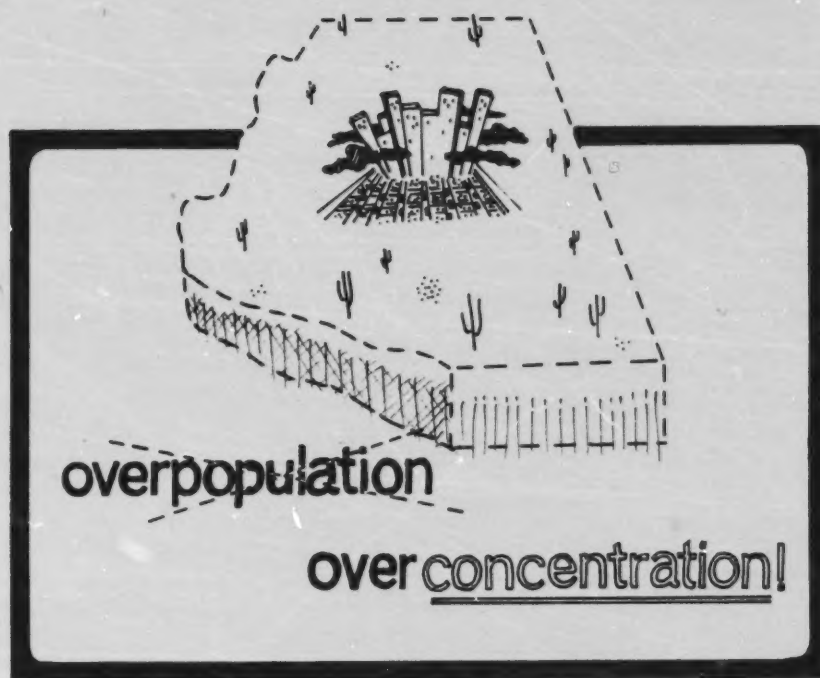
A better understanding of our ecosystem and its function, and a consideration of our uses of our natural resources can help prevent such errors in the future.

BASIC CONCEPT NO. 2 — A concentration of human populations can lead to environmental deterioration.

A. Environmental pollution problems are complex situations, requiring careful study and consideration.

The current pollution of our earth comes in many different forms and from as many sources. Air and water pollution, pesticide residues, natural organic pollutants, solid wastes, radioactive or nuclear wastes, and noise are just a few. Each form is created by different situations and for different reasons.

Pollutive substances may have biological or chemical impact affecting the oxygen cycles in a lake or atmospheric composition. Yet many pollution problems originate with social or political situations. As an example: the major cause of smog and air pollution in Los Angeles, or Phoenix, is the automobile. But how do we change the life-styles of people to limit this automobile use?



Mexico's growing agricultural capacity uses vast amounts of pesticides and herbicides. In the valleys of Sonora and Sinaloa these materials are washed into the Gulf of California with irrigation and rain. The detrimental effects upon the rich Gulf ecosystem are not completely known—but the tremendous values of shrimp and fish from these waters are most certainly affected. What helps the farmer to produce food, hurts the fisherman, who also produces food for the world. And both contribute to the economy of a rapidly-growing nation. Should we side with the fisherman and his problems against the farmer and his? We are also forced to look at such things as the balance of payments between countries, unemployment rates, and hungry people.

So the solutions to pollution problems, not only require knowledge of natural systems, cycles, and interrelationships, but real world social and political systems, cycles, and interrelationships. A clean environment will always represent a trade-off; something positive—something negative, but hard decisions which we must make.

B. The amounts of waste materials per capita is increasing.

Increased populations, the concentrations of those populations, and current life-styles have contributed significantly to a massive increase in per-capita waste. Man is literally being inundated by his own waste.

In 1900, each American used an average of 58 pounds of paper per year; by 1973 this figure had increased to 639 pounds per year. In 1970, 5.3 pounds of solid waste was produced daily by each man, woman, and child in our country. By 1980, that waste is projected to be 8 pounds per day. This amounts to over 387 billion pounds of solid waste produced each year. If this waste was equally distributed over Arizona, it would bury the state to a depth of 7 feet in a single year.

What do we throw away? A typical ton of waste in the U. S. contains approximately 920 pounds of paper products; 440 pounds of food and yard wastes; 200 pounds of glass; 160 pounds of metal; 140 pounds of wood, and 140 pounds of cloth, rubber, plastic, and leather.

To decrease the amount of solid waste that man generates may require modifications of individual and cultural value systems and individual life-styles. Such changes may not be feasible. A practical approach might be to accept increasing amounts of solid wastes and concentration on methods of utilizing waste in a productive manner. Waste materials cannot be thrown away—Dr. Barry Commoner has reminded us that “there is no such place as away.” The materials go somewhere and have a variety of effects upon our environment.

The ideal situation would be a two-fold approach to the problem—a modification of value systems and an intensification of recycling and reuse of *all* waste. Today's recycling of aluminum, glass, tin, and paper are only beginnings. The future must bring a recycling and reuse, in some form, of *all* waste.



1900

today

- C. The safe and proper disposal of waste products is important to the maintenance of environmental quality.

Without the proper disposal of waste products, severe environmental damage occurs. Examine the historical disposal of sewage in rivers, lakes, and the sea. Investigate the

problems of land-fill dumps and their "disposal" of solid wastes—with their Pandora's box of leachings into underground and surface water sources. Today we not only are faced by increasing volumes of these more familiar items but with the safe and proper disposal of such things as radioactive wastes, pesticides (such as Kepone), or herbicides. Because of the extreme "life" of some of these products—or the compounds which they break down or combine into, they cannot be disposed of in traditional ways. In Oregon's eastern desert, more than 25,000 barrels of residue from the manufacture of herbicides has been stored for some years. The barrels are rusted and leaking and this material soaks into the earth—to travel where? With what results? Many suggestions have been made and a number of solutions tried—but as yet we have no safe disposal of radioactive wastes or for many of the more virulent chemicals we produce and use.



Living organisms in large lakes and rivers have been changed or destroyed by wastes from cities and industries. Even ocean ecosystems are affected by the disposal of oil from tankers, industrial and agricultural wastes, and human sewage. New York City daily hauls huge barges of solid waste far to sea for disposal.

Rural areas are not immune—farm uses of nitrogen fertilizers have increased the nitrate content of wells and underground water to the point of polluting water supplies. And the concentration of livestock in feedlots creates parallel problems as their wastes accumulate.

The safe disposal of our waste materials is essential in maintaining a clean, productive environment. Unsafe or improper disposal alters the environment and affects all organisms of that environment, and ultimately, man's ability to maintain his quality of life.

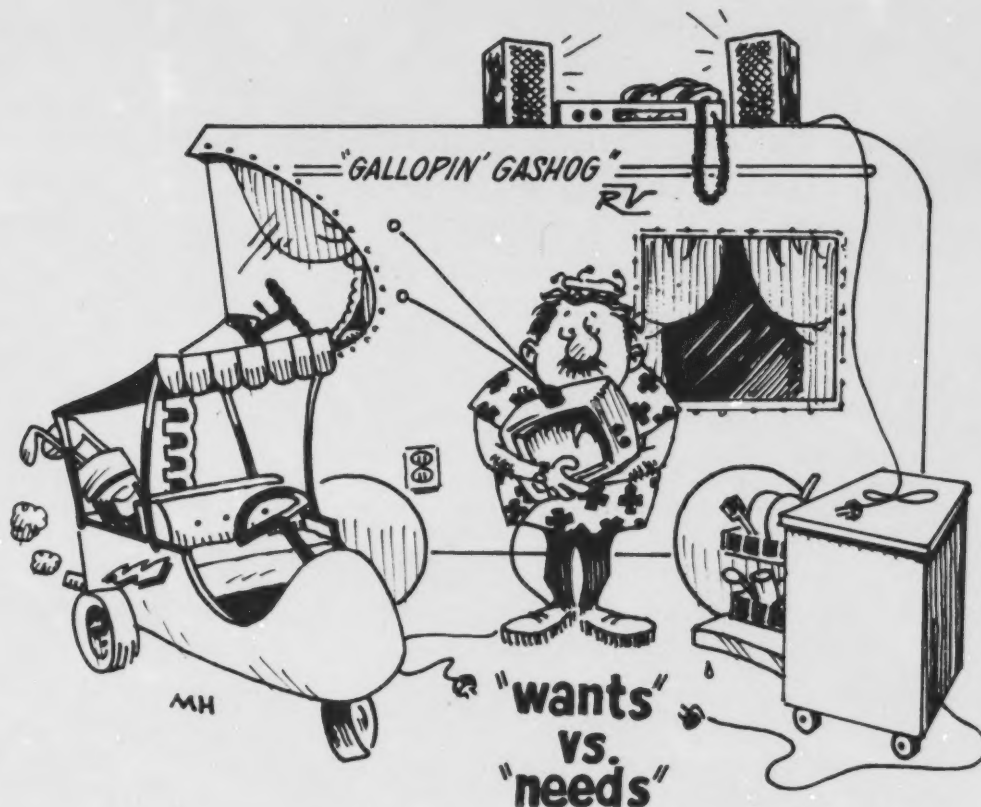
CONCEPT NO. 3 – Man needs to reexamine his life-style.

A. Man's needs and his desires are often in conflict.

Man has not only changed his wants and needs in recent years, but also his life-style. His home today is almost certainly larger than in the past; he now is more likely to use electricity for cooking and heating than natural gas. A few years ago screened porches were the way to beat the summer heat—today electrical refrigeration takes over when temperatures soar. Instead of the family gathering in one place to hear "Fibber McGee and Molly" or "Jack Benny" on the radio, today father may be watching pro-sports in the family room, mother and a neighbor may be enjoying "All in the Family," while the children are absorbed by "Star Trek"—all in different rooms and on separate television sets.

When we are thirsty we reach into the refrigerator for an aluminum can rather than the returnable bottle of the 1940's. Today we drive two blocks to the supermarket for a fantastic variety of frozen, dehydrated, processed, premixed, and precooked foods. Not too many years ago we walked to the corner store and bought canned goods or fresh foods.

In 1946 most of us would have caught buses or streetcars to go to work or school. Today, when the electric alarm clock rings, some of us hurry to the master bath to use



our electric razor—while in another bathroom the children are fighting over the electric toothbrush or electric hairdryer. Mother is frantically drying a pair of trousers in the electric dryer for one of the boys. After a quick cup of electrically-perked coffee, mother hurries the kids into the station wagon and father drives the family's second car to work.

Exaggerated? Not too much. The facts are, that since 1946 electrical power usage in the United States has increased 530 percent, while population increased 60 percent.

The purchase and use of convenience items, time and labor-saving devices, comfort-related products, and luxuries is not totally negative—the materials must be meeting the “perceived desires” of a large group of people. But do we really need them, and are they worth the environmental costs that come with them? What are we willing to give up in return for a better environment?

B. CONSUMPTIVE PRACTICES ARE CONSTANTLY BEING EXPANDED BY OUR ABILITY TO PRODUCE AND CREATE WANTS AND MARKETS, WHICH AFFECTS THE RATE OF RESOURCE USE.

Major consumptive changes have occurred in the United States since World War II. You need only to visit a vacant lot or to watch from the window of your car to see the massive utilization of plastics and aluminum—two materials used sparingly before that time. The country's changes in consumptive practice are too numerous to mention in any detail, but the following demonstrate a pattern. Synthetic fibers, detergents, fertilizers, and plastics are derived, in whole or in part, from petroleum, a nonrenewable resource. In addition, the production of synthetic fibers, detergent, plastics, and aluminum all demand large amounts of energy in the manufacturing process, compared with the substance they replace. A further problem is that these new materials do not “break down” in the environment as readily as the former substance, thus creating part of our pollution crisis.

The automobile engine has changed from a low-powered, low-compression engine into the high-powered, high-compression engine of today. Tetraethyllead must be added in greater amounts to prevent engine “knock” in these high-compression engines. This tetraethyllead is dispersed into the atmosphere by engine exhaust, and is toxic to plants and animals. Scientists, studying the ice at the South Pole, have discovered the history of this lead, clearly documented in the layers of ice. According to Dr. Barry Commoner, there has been almost a doubling of the amount of lead emitted into our environment, per vehicle-mile traveled, since World War II. This increase in lead in the atmosphere can be directly correlated to the development of the high-compression engine. The recent Federal mandate for nonlead fuel is a step in the right direction.

Similar changes are occurring in agriculture, in the transportation processes, in our throwaway national philosophy, and our advertising compulsions. Commoner says that these changing patterns in economic growth are the major reasons for the environmental crisis.

CONCEPT NO. 4 — Long-range planning is required to meet the natural resource and sociologic needs of future generations.

A. To achieve specific objectives in human well-being, effective resource planning involves the application of social, as well as scientific, knowledge.

Long-range planning, with specific objectives in regard to human needs and wants, can only be accomplished by the input from a variety of disciplines.

In undertaking the extraction or harvest, processing, and remanufacture of natural resources, scientific knowledge is not sufficient for long-range planning. Because we know how to extract and reshape a resource to our needs should not be total justification for doing so. There are other knowledges which must be applied. Other scientific knowledge can let us understand the biological impacts of the technology. The social sciences may add constraints relating to religion, attitudes, aesthetics—what is, or what is not, acceptable to our present, or desired, life-styles.

Just a few years ago we built a highway through the Virgin River Canyon; we channelized a major portion of the lower Colorado River; and we pumped irrigation water from beneath the earth until it became economically infeasible, and then we left the land fallow and exposed to wind and water erosion. We have built, and dredged, and pumped without long-range understanding of the impact upon the environment—or equally, the impact upon people.

What has been the impact upon people whose farmlands were lost? What becomes of the farm family whose wells cannot produce irrigation for their lands? Are these people forced from a rural life-style into an urban way of life? Is their economic status changed? Do their children have the same opportunities? John Steinbeck's book, *The Grapes of Wrath*, was written about just such people—people displaced by the overuse or abuse of a natural resource. Could this disruption have been avoided by long-range planning?

Today, some of these projects would not be undertaken; we have begun to understand our environment and our attitudes are changing. Our attitudinal changes bode well for a quality environment for future generations.

B. Economic efficiency does not always result in conservation.

A criteria for many natural resource uses has been that it was economically feasible and that it resulted in an immediate profit. While the economics of a project are



important, there are other pluses and minuses which must be considered. The dredging of a river or the removal of streamside vegetation may be economically feasible and may return an immediate profit to certain river or water users. But what are long-range considerations? In the Salt River Valley, some of the most productive farmlands in the west have become freeways, parking lots, shopping centers, and subdivisions. The land has become too valuable to be used for farming. The short-term profit was taken and economics alone have dictated land use. There are several questions: With world populations increasing and with its increasing demands for food—would long-range planning have disagreed with short-term profits in the case of these farmlands? Or, should desert lands be irrigated? There is nearly 7000 years of agricultural history which strongly suggests that this is ecologically wrong.

Long-range planning would take short-term economics into consideration—but only as a single factor. All known factors must be considered in the use of natural resources.

CONCEPT NO. 5 — Man has the ability to maintain a viable, quality environment for himself and for future generations.

A. Man's awareness of environmental deterioration has increased.

For most of man's history, he has struggled to exist—every meal and each night's shelter was in question. It has only been in the past few hundred years that any number of people have exceeded this level of existence. As men achieved a degree of physical security there was time for contemplation, consideration, and analysis. Early thinkers began to recognize impacts upon the natural world. Aristotle made comments about natural occurrences and man's influence, as did Thomas Jefferson. The writings of Thoreau in the 1800's and the comprehensions of Aldo Leopold in the 1940's showed that a few people had begun to have in-depth understandings of the environment and man's influences upon it. But they were prophets, preaching to ravens in the wilderness.

It was only in the late 1960's, culminating with Earth Day in 1970, that large numbers of people were awakened to the problems of environmental degradation. The great photograph of earth, taken by our space explorers, starkly detailed our small world and its limitations. That small, blue orb, suspended in black space, drove home the realization that our environment has limitations and that there must be an increasing concern for that environment and our relationships with it.

B. Environmental decision-making is the responsibility of every citizen.

Those who made the decision to test atomic weapons in China scattered "fallout" worldwide; "fallout" which may affect us all for generations. The decisions to use our finite petroleum resources for luxury items, for energy sources, or for unimportant products, will certainly shorten the life of this resource. And a community's decisions in regard to disposal of sewage or solid wastes may bring problems in years to come. Such decisions not only affect us, but will have environmental impacts upon generations yet unborn.

It is time we became involved in such decisions—as individuals, as communities, as states—and our representatives, well informed as to our decisions, should make

decisions as a nation. It is our destiny that is at stake. Such decisions are our rights and our responsibilities.

C. Interaction and experience with nature is psychologically important to, and valued by, man.

Man, developed in a savannah environment of grasslands, trees, and open space, has continued to have an affinity for the out-of-doors. The earliest records of man are drawings of native animals on the walls of caves. Nature has been a dominant theme in art, literature, and music. In almost every civilization, some recognition of the desire for contact with nature has been publicly expressed. From Babylon to the reign of the "Sun King" of France, gardens, such as the Versailles and the hanging gardens of Babylon, of dazzling proportions and filled with exotic plants were built surrounding royal habitations. From the earliest recorded history, man's favorite leisure activity was hunting. Kings and princes, philosophers and popes chose hunting as their favorite recreation (dancing was second). Although it was only those who had leisure who participated in out-door recreation, the desire for such experience has constantly been expressed in the folk songs and folklore of the peasant as well.

In recent times, as we have become aware of the degradation of our environment, there has developed an increasing awareness of the beauty of an unspoiled world, and a desire to experience this quality of life. Today our wildernesses and natural areas, our National Parks and wildlife refuges are being seriously impacted by people in the expression of this desire. A survey of the economics of backpacking, hiking, fishing, climbing, hunting, birdwatching, and nature photography would clearly define the values of the natural world to modern man.

SUGGESTIONS AND ACTIVITIES

Mathematics

A. HOW FAST IS ARIZONA GROWING?

From the following figures, figure what was the annual growth rate of Arizona for each of the last two decades:

1950	—	749,587	1969	—	1,725,000
1959	—	1,261,000	1970	—	1,752,122
1960	—	1,302,161			

If the annual rate for the last decade continues, what would the population be at the end of 1979?

What more of the following will be needed to supply the increased population in 1979 (compared to 1969)?

1. Dwellings (figure an average 2.73 people per household)
2. Land for dwellings, acres (figure one-fourth acre per dwelling)
3. Water for household use (figure an average of 200 gallons per person; this is the average amount for home use only and does not include the amounts used for irrigation and industry). (*Concepts 2A, 3B*) (Intermediate)

B. WASTE PAPER — WHERE'S IT GONNA GO?

Here are estimates of the amount of paper used, in pounds per person per year in the United States.

Year	Pounds
1920	66
1970	500
2000	1000

Obtain a projection of the population in Arizona for the year 2000, or ask students to make a projection based on the previous activity. Based on this projection, calculate the amount of paper that will be used in the year 2000 in Arizona.

If all this paper becomes waste, how much landfill space would be required for it (figure 200 cubic feet per ton)?

Ask students if they can think of ways to use the discarded paper so it will not have to be taken to the landfill. (*Concept 2B*) (Intermediate)

C. WILL THERE BE STANDING ROOM ONLY ON THE WORLD?

To provide students with a physical model that represents the increase of the human population on earth, try the following:

On a large table mark off an area 1 meter square, or use your desk top. Get a box of counting blocks. One block will represent 1 person. Start your population with 2 "people." Every 30 seconds, add 8 blocks (people) to our world. This represents the people being born every 2 seconds in real life. Take away 3 blocks (people) every 30 seconds. This represents those people who die in real life every 2 seconds. What happens to your world after a few minutes? After 10 minutes?

The same thing is happening in the real world. Each second, 4 babies are born and 1.6 people die. Every second we add 2.4 people to the world.

Follow-up calculations: How many people are added to the world in a minute? In a day? In a year?

Take a field trip to a cemetery and find out if people are living longer now than years ago. A chart such as the following can be used to calculate the results:

DEATH RATES

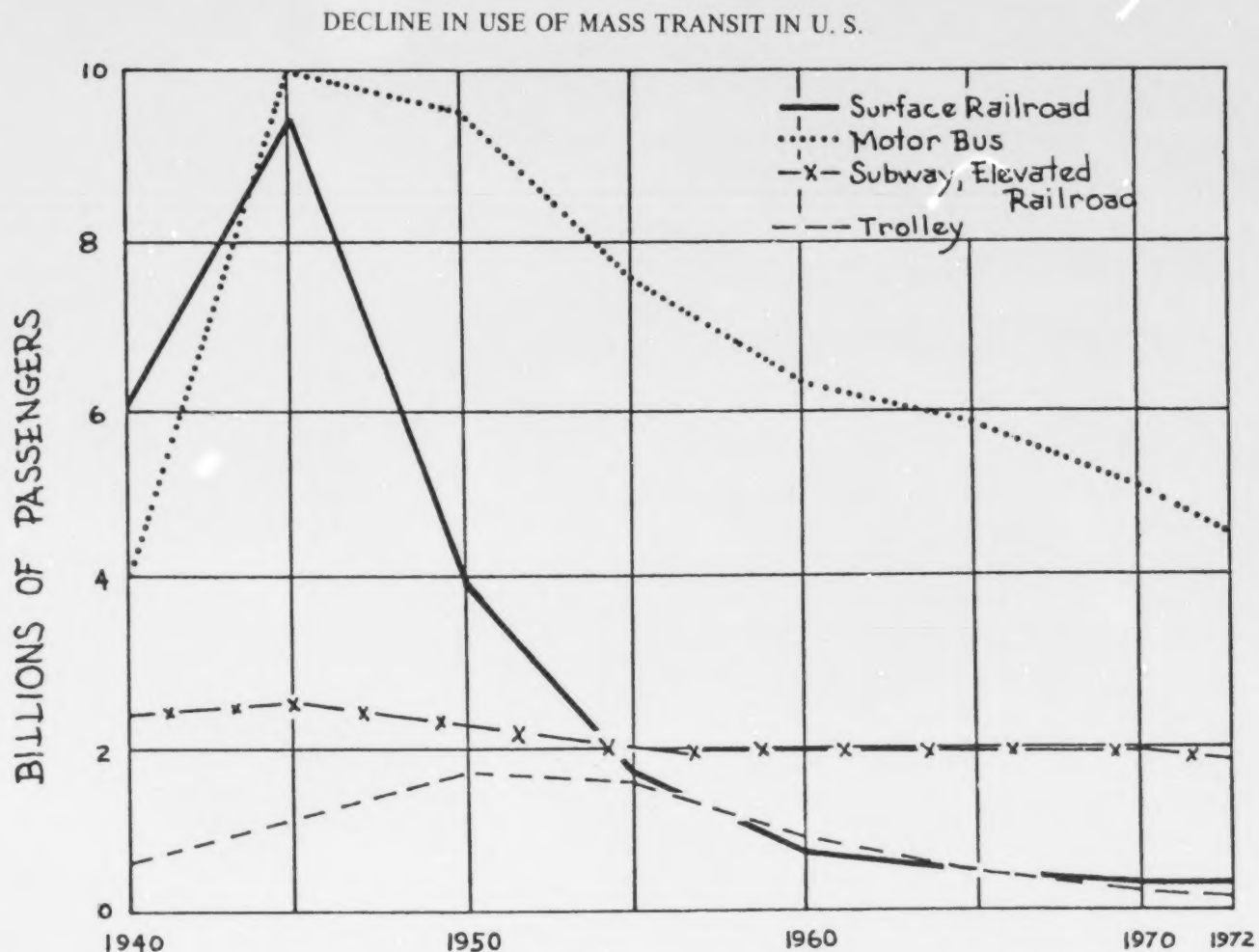
Age at Death	1821-1870	1871-1920	1921-1976
0 - 5			
6 - 10			
11 - 20			
21 - 30			
etc.			

Age at death should be calculated. The results should be listed in the time period when death occurred. What is happening to the population of the United States based on the data collected? (Concept 2A)

(Junior High)

D. WHY THE DECLINE IN THE USE OF MASS TRANSIT IN U. S.?

Present the following graph to the students and have students work individually or in small groups to answer the questions which follow.



Source: American Transit Association, '72-'73 Transit Fact Book (1973)

How many people use any of these in your community each week? Month? (Conduct a survey to find out)

1. When was mass transit the most popular in the U. S.?
2. How many billion passengers were transported in 1945?
How many were transported by surface railroad?

3. How many billion passengers were transported in 1970?
4. Is the number of passengers using mass transit increasing or decreasing?
Why do you think *this* is happening?
5. What is presently the most popular form of mass transit?
6. Which form of mass transit is the least popular?
Why do you think this is so?
7. Which forms of mass transit have you used?
Which forms are available in your community?
8. Do you think mass transit will become popular again now that gas prices have risen? (*Concept 3A*) (Junior High)

Language Arts

A. WELCOME TO THE ENVIRONMENT

Before young children can begin to appreciate the role of man in the environment they need to understand what the environment is. Start the definition by action. Take the students for a walk around the school. Have the students listen, smell, touch things around them. Taste (where appropriate). Talk about the things you observe. The many things around make up the environment. We all live in the environment.

To go beyond the definition level it would be easy to get to the values level after this short trip. Continue with these questions and activities:

What things do you like in the environment? Make a collage or painting that shows the things you like.

What things would you change? Make a list. Tell why each should be changed.

Write a poem or story about your environment. Read it to the class.

Draw a fish. Draw the things you would find around it. This is the fish's environment. Is it the same as ours?

Does everyone have the same environment? What makes an environment good?
(*Concepts 1C, 5A, 5C*) (Primary)

B. FEELINGS

To begin to help children appreciate the environment it's helpful to place them in situations where they have to make value judgments. Start by asking children what makes them happy. Have them find a picture from a book or magazine of one thing that makes them happy and explain why it makes them happy.

Then, have them find a picture of something that makes them feel sad and explain this to a classmate.

Next, have pictures of various aspects from the environment and ask, "How do you feel when you see . . . (such things as) . . . rain? Litter? Fire? A dead animal?"

Follow this up by having the students act out or write about:

What makes a hungry animal happy?
What makes a thirsty animal happy?

Follow-up questions might be:

What things do animals need?
What do plants need? How are we like plants? How are we like animals?

Finally, everyone should do something to make someone happy. How did you do it?
(Concepts 1C, 5A, 5C) (Primary)

C. STRANDED ON A TROPICAL ISLAND

Put the class into the situation of being stranded on a deserted tropical island. Their goal is survival. Have them write a short essay on what they would do to survive and what natural materials they would need and use.

After they turn in the essays ask how many thought into the future or were concerned with their immediate needs.

To make this activity more challenging limit the amount of selected natural resources such as fresh water, wood, and edible plants. (Concepts 3A, 3B, 4A) (Intermediate)

D. AN ECOSYSTEM THROUGH WHOSE EYES?

After studying a particular ecosystem have class members choose one of the members of the ecosystem (a plant or animal). An analysis should first be made of how this member is interrelated with other living and nonliving aspects of the ecosystem (including the activities of man).

Then have students write a story through the eyes of that member, indicating what's happening to the ecosystem and making predictions of what the ecosystem will be like in the future. The stories should then be read to the class.

Follow-up discussion could deal with such things: Is the ecosystem you studied protected? Are new laws needed? Who should be responsible for protecting it? Predict what would happen in your ecosystem if one of the living things disappeared. If one of the nonliving factors changed greatly.

As a follow-up activity the class can choose its favorite story of those read and make and put on a play based on that story. (*Concepts 1A, 1C, 5C*) (Junior High)

Fine Arts

A. DON'T THROW IT AWAY – RECYCLE IT

Recycle means "to use over." Have class list some of the things they throw away. How many of these could be reused? Have each student select one of the things they think they could reuse and hold a recycling fair to display the ways things can be reused. Who found the most ways for any one item?

Related discussions and activities:

Why is recycling important? (Most things are made from natural resources: some are renewable; i.e., new trees can be grown, and some are nonrenewable; i.e., aluminum cannot be replaced. Recycling conserves our natural resources, makes less garbage, and saves money.)

What does a recycling plant do? Find out. Bottles and cans go in the garbage. Where do they go? What happens to them?

Collect some reusable items such as glass jars and aluminum cans. Either sell them and use the money to help the environment or make a present out of these items. If you make a present add a message that lists five ways to recycle things. Give it to someone you like. (*Concept 2C*) (Intermediate)

Science

A. LIVING THINGS GROW AND CHANGE

There are many things in the environment. Some are living and some are not. Living things grow and change. They make more living things and they can die. For a young child to begin to understand the interactions between man and his environment he should first understand the basic differences between living and nonliving things.

Take the students to the school site and have them find five living things. Show them to a friend. Now find three nonliving things. Discuss differences between living and nonliving things.

Have students bring the three nonliving things back to the classroom. Give each group of students three seeds and have them plant all six items. Water all six. Keep a record. What happens? How are living things different?

While you are waiting for something to happen with the planted items have students look for other nonliving things in the school. Make rubbings of them using crayon, chalk, or pencil. Compare the rubbings with the objects from day to day. Do nonliving things change? (*Concept 1A*) (Primary)

B. SOUNDS AROUND YOU

Sounds are all around you. They are part of your environment. Take students on a sound hike to different places in the school and on the school site. Listen for 60 seconds. Have students think of one sound they heard and draw a picture showing what made that sound.

A follow-up discussion can be had about the following: What sounds help people? Have students make a collage of the pictures they drew that show sounds that help people.

Were any sounds natural sounds? Make a collage of natural sounds. Were any sounds man-made?

Follow-up activities could involve students taking tape recorders to different locations in the environment. Bring the recording back to class and have classmates guess where they were recorded. (*Concepts 1A, 1B*) (Primary)

C. WHAT IS NOISE?

Discuss students' ideas about noise. What is it? Do they like it? Is it good for you?

Have students conduct a survey of their school or home and record all the noise producers. How do they affect people? What can be done about noise? How can we help?

Some additional thoughts and activities. Have students draw a cartoon that shows how noise might bother someone.

Some noises can cause hearing damage. Some people hear a lot of noise in their jobs. Make a list of these jobs. How are people protected from noise? Try to find out.

Be a noise-detective. Use a tape recorder. Record the noises in your classroom. Identify the noise producers. Can you lower the noise in your classroom? Try it. (*Concepts 1A, 1B*) (Intermediate)

D. LITTER, LITTER, EVERYWHERE

Have the class work in teams of three. Each team should be assigned to a different location in and around the school. Have them complete the following data sheet:

OBSERVATIONS OF LITTER IN OUR ENVIRONMENT

Describe the Litter	Where Did You See It?	How Was the Litter Harming the Environment?	What Did You Do About It?

Follow-up discussions:

Litter is trash left on the ground. What is wrong with litter? What does it do?

Make a litter bag. Color it. Take a walk around the school. Pick up the litter and place in the bag. Utilize the idea above to find out what types of litter are found. Who puts the litter there? Could any of the litter have been used again? Find a way to reuse some of the litter. Where was lots of litter found? Try to have a litter barrel placed there. (*Concepts 2B, 2C*) (Intermediate)

E. ENERGY AND YOU

Start by having students collect pictures of energy users and energy sources. Each group of two students can make a collage. This will give you an idea of their understanding of energy sources. Try these activities that demonstrate energy sources:

1. Put a jar of water in the sun. Measure the temperature. Wait an hour. Measure again. What happened? What was the source of energy?
2. Make a pin wheel. Blow on it. What happens? How is this like a windmill? What was the source of energy?
3. Survey your home. List all the ways you use energy. Have a family meeting. Plan ways to save energy. Try it. Keep records. Did you cut down use of energy?
4. Survey your school. List all the energy users. How can energy be saved? Make a list of suggestions. Meet with your principal. Ask him to help you. Try some of the suggestions.
5. Much of our fuel is imported. Find out where it comes from. (*Concept 3B*)

(Intermediate)

F. THE HOUSE THAT JACK BUILT

Read this revised story to the class and have them draw pictures to represent each new part of the story.

1. This is the house that Jack built.
2. This is the spray (DDT) with the poisoned salt, that lay in the house that Jack built.
3. This is the malt that was sprayed with the salt, that lay in the house that Jack built.
4. This is the rat that ate the malt, that was sprayed with salt, that lay in the house that Jack built.
5. This is the cat, that killed the rat, that ate the malt, that was sprayed with the salt, that lay in the house that Jack built.
6. This is the dog, that helped the cat, that killed the rat, that ate the malt, that was sprayed with the salt, that lay in the house that Jack built.
7. This is the cow with the crumpled horn, who ate some malt and some poisoned corn, that tossed the dog, that helped the cat, that killed the rat, that ate the malt, that was sprayed with the salt, that lay in the house that Jack built.
8. This is the maiden all forlorn, that milked the cow with the crumpled horn, who ate some malt and some poisoned corn, that tossed the dog, that helped the cat, that killed the rat, that ate the malt, that was sprayed with the salt, that lay in the house that Jack built.
9. This is the man all tattered and torn, that shared with the maiden all forlorn, that milked the cow with the crumpled horn, who ate some malt and poisoned corn, that tossed the dog, that helped the cat, that killed the rat, that ate the malt that was sprayed with the salt, that lay in the house that Jack built.
10. This is the farm full of poisoned salt. That should be a sign for us all to halt this spraying of grain with a poison aim. That killing of pests and all the rest. That spraying of he and the spraying of she is really the killing of you and me. That's all — for the house that Jack built.

Discuss the story. What is making everyone sick? Can this happen?

Take a survey of the pesticides that are used at school and at home. Have the janitor or your parents help. List what is in each pesticide.

Other items: How should pesticides be applied? Stored? How do pesticides travel through a food chain? Make a food chain poster. Show how pesticides can travel through it.

Write a paragraph. Tell why pesticides should be used with care. (*Concepts 1A, 1B*)
(Intermediate)

G. DOES NOISE AFFECT SIMPLE LEARNING?

Here's a chance for the students to carry out an experiment with the whole class to answer this question. One form of simple learning is running a maze. The maze shown below will be used. Have a group of three to four students organize this experiment.

They should divide the rest of the class in two groups. Each student will do the maze three times using a pencil. They should record their time for completing each trial (a clock with a second hand is needed).

The two groups will try the mazes under different conditions. The control group will work under quiet conditions. The experimental group will be interrupted by loud noises such as banging, doors slamming, loud music. The best way to do this is by using earphones and cassette tapes with loud noises on them.

The students conducting the experiment should find the average time for each group on each trial. (Done by adding the times for each student in the group on that trial. Divide the total by the number of students in the group.)

The results can then be placed on a graph such as the following:

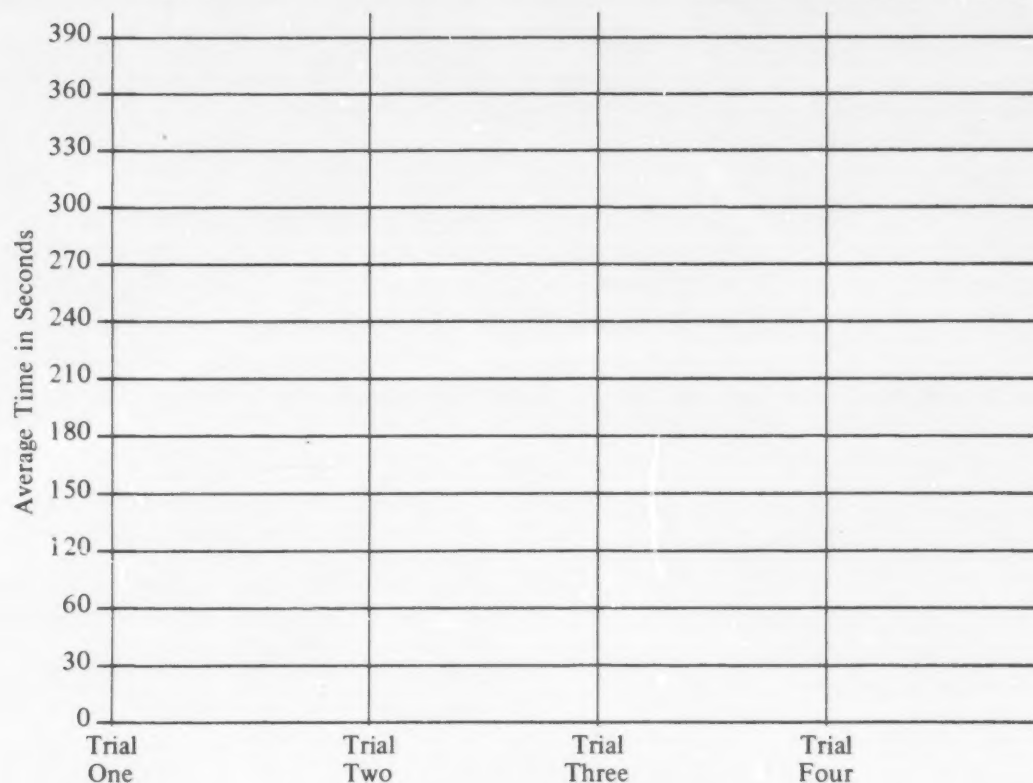
EFFECT OF NOISE ON SIMPLE LEARNING

Legend: Δ Control

Name _____

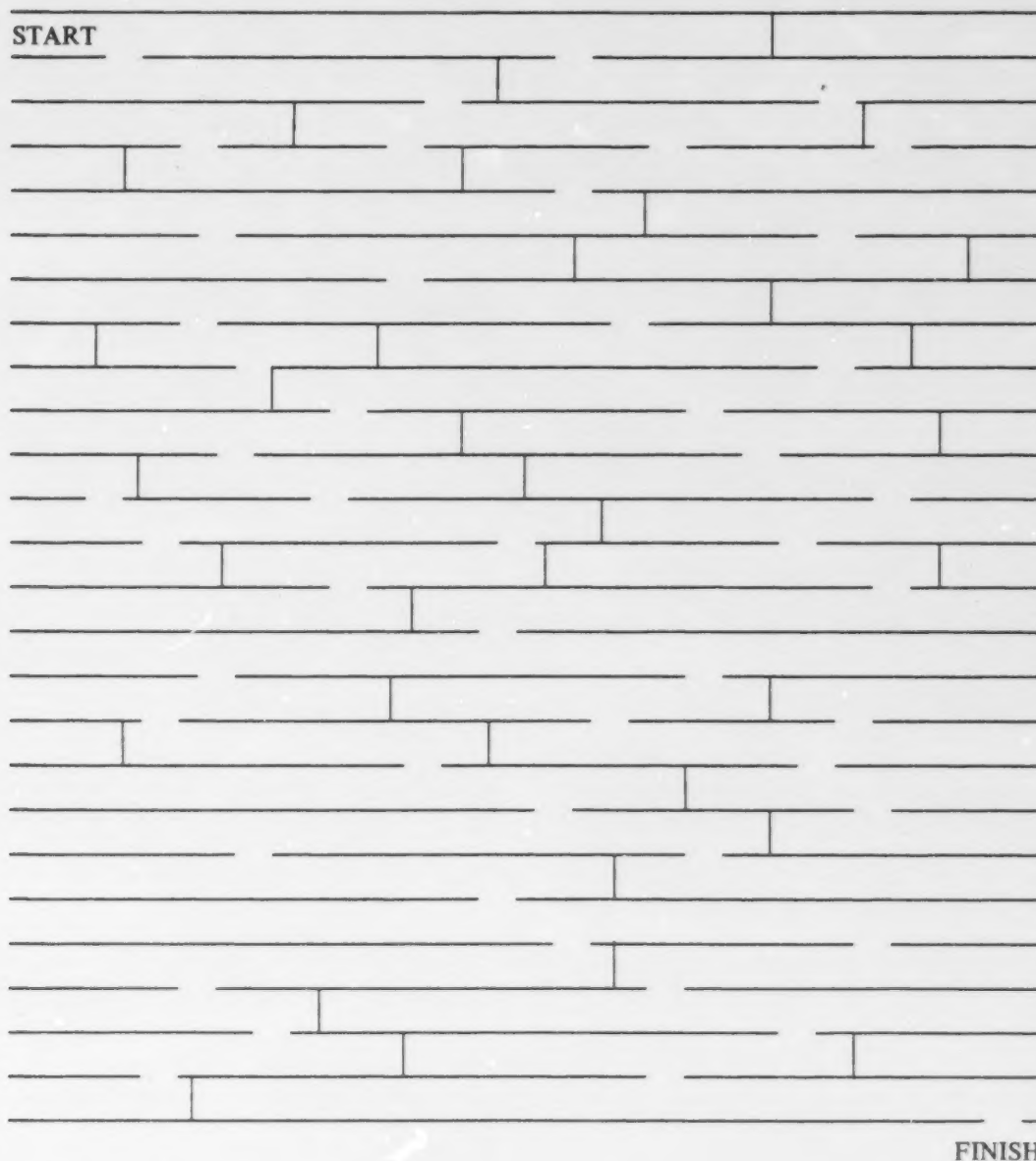
$\circ$ Experimental

Date _____



Did the noise affect the time it took to run the maze? What would have happened if soft music was used. Try it.

How many noises affect simple daily activities like driving a car, eating, sleeping, playing a game, homework? (*Concepts 1B, 5C*) (Junior High)



H. ARE THERE SPECIAL AREAS OF YOUR SCHOOL OR SCHOOLYARD WHERE LITTER IS FOUND?

Organize the class into groups of three and have each group assigned to a different area of the school or school grounds. Have them collect the following information: places where they see litter, kind of litter it is, amount of litter. Have each group draw a map of their area. Use symbols for the types of litter they found; i.e., paper, plastic, glass, cans, other. Collect all the litter they find.

Follow-up activities and discussion: Did they find a place where no litter was found? Why is there no litter there?

Start an antilitter campaign. Discuss how the class can educate their friends at school without causing more litter or solid waste? Example: Try creating a spot announcement about preventing litter. See if you can give it to other classes.

Make a survey of your community. Are there places where litter collects? See what you can do about it.

Measure the volume of the litter you found. If this much builds up in one day, how much will there be in a week? Month? Year? (Hint: Volume = length X width X height)

Use some of the litter you found to make a garbage (garbage collage).
(Concepts 2B, 2C)

(Junior High)

I. ENERGY USAGE: PAST, PRESENT AND FUTURE

Increases or decreases in energy consumption reflects a change in one's life-style. This activity provides an opportunity for students to inventory the variety and amount of their families' energy use in the home. By interviewing grandparents or elderly people in the neighborhood students may also gain some idea of how energy use has changed in the past 40 years. Finally, based on this data, students should be able to make predictions about future energy demands.

First, have the students take home Figure 1 and have their parents help complete it by listing all the appliances in the home that require energy to operate. Then have the parents place a check in the 10 years ago and 20 years ago columns for those appliances which they had available 10 and 20 years ago. Record also how many people were in the family at the time.

Then, have students ask grandparents (or elders in the neighborhood) to check those items on the now list that were used 30 and 40 years ago.

FIGURE 1: INDIVIDUAL ENERGY USE CHART

Appliance	Now	10 Years Ago	20 Years Ago	30 Years Ago	40 Years Ago
TOTAL kwh/mo.					
No. in family					
kwh/mo./person					

By using the Electrical Energy Use Chart (Figure 3), fill in the estimated total kilowatts per month used by each appliance and add up the grand total at the bottom.

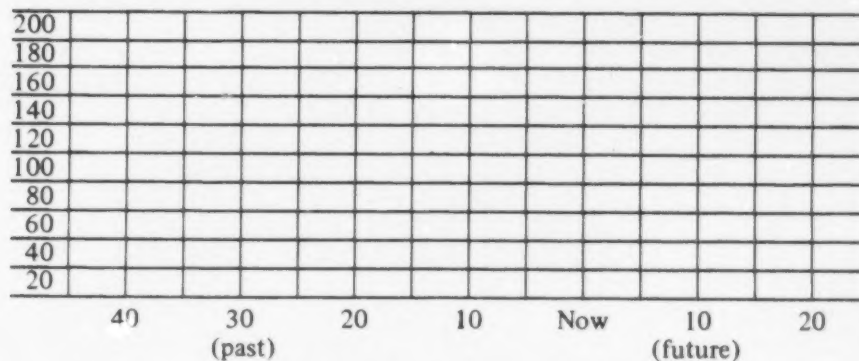
Follow-up activities and questions:

Does the completed Chart 1 accurately reflect the total energy used to maintain the life-style today? 10 years ago? 20 years ago? 30 years ago? 40 years ago? What is missing? Can you figure out a way to more accurately represent the energy used? Try it. Keep careful notes of what you tried and what problems you ran into.

Divide the total kilowatt hours per month by the number in the family at each of the time intervals. This gives you a kilowatt hour usage per month per person.

Graph the results in a bar graph such as the following:

FIGURE 2: KILOWATT HOUR USAGE PER MONTH PER PERSON



Using the graph, predict the use of electricity per person 10 years from now, 20 years from now. What might affect the accuracy of your predictions? (*Concepts 3A, 3B, 5A*)
(Junior High)

FIGURE 3: ELECTRICAL ENERGY USE CHART
Estimated Energy Consumed by Home Appliances in a Month

	Average wattage	Estimated kilowatt hours monthly		Average wattage	Estimated kilowatt hours monthly
<i>Food Preparation</i>			<i>Comfort Conditioning</i>		
Blender	390	1	Air Cleaner	50	18
Broiler	1,440	8	Air Conditioner (room)	1,570	114
Carving Knife	92	1	Bed Covering	180	12
Coffee Maker	890	9	Dehumidifier	260	31
Deep Fryer	1,450	7	Fan (attic)	370	24
Dishwasher	1,200	30	Fan (circulating)	88	4
Egg Cooker	520	1	Fan (rollaway)	170	12
Frying Pan	1,200	15	Fan (window)	200	15
Hot Plate	1,260	8	Heater (portable)	1,320	15
Mixer	130	1	Heating Pad	65	10
Oven, Microwave	1,500	25	Humidifier	180	14
Oven, Self-cleaning	4,800	95			
Range	8,200	97	<i>Health & Beauty</i>		
Roaster	1,340	17	Germicidal Lamp	20	12
Sandwich Grill	1,160	3	Hair Dryer	380	1
Toaster	1,150	3	Heat Lamp (infrared)	250	1
Trash Compactor	400	4	Sun Lamp	280	1
Waffle Iron	1,120	2			
Waste Disposer	450	3	<i>Home Entertainment</i>		
			Radio	71	7
			Radio/Record Player	110	9
			Television (b&w)	240	30
			Television (color)	330	40
<i>Food Preservation</i>			<i>Housewares</i>		
Freezer (15 cu ft)	340	99	Light Bulb	100	15
Freezer (frostless, 15 cu ft)	440	147	Clock	2	1
Refrigerator (10 cu ft)	240	60	Floor Polisher	310	1
Refrigerator (frostless, 12 cu ft)	320	110	Sewing Machine	75	1
Refrigerator/Freezer (14 cu ft)	330	94	Vacuum Cleaner	630	4
(frostless, 14 cu ft)	620	152			
<i>Laundry</i>			To calculate the number of KILOWATT HOURS (kwhrs) used per month multiply the wattage by the month of hours you expect the appliance to use in 1 month. This will be the number of watt hours. Divide by 1000 to get KWH.		
Clothes Dryer	4,860	83	Electric Coffee Pot used 1/2 hour per day:		
Iron (hand)	1,010	12	$\frac{15 \text{ hrs/mo} \times 890 \text{ watts}}{1000} = 13.4 \text{ kwh/mo}$		
Washing Machine (automatic)	510	9			
Washing Machine (nonautomatic)	290	6			
Water Heater (standard)	2,480	352			
Water Heater (quick recovery)	4,470	401			

J. DOES HOME INSULATION CONSERVE ENERGY?

We often talk about the benefits of home insulation for conserving energy. Does it? How? The following activities can be conducted to answer these questions.

First, to allow students to demonstrate their problem-solving skills, have them work in groups of three or four to design an experiment using bottles of same size and various materials for covering the bottles: aluminum foil, wool, cotton, paper, clean plastic wrap, etc., to determine how heat may be retained in water. Have each group make a

graph of their results. Then, consider: Which material conserved the most heat? Did the graphs reveal any contradictory results? How might these be explained?

Next, have the students try another experiment to see what material will insulate an ice cube most efficiently. Provide them such material as sawdust, pencil shavings, aluminum foil sheets, shredded newspaper, cotton balls, cotton materials, etc. Again have them keep records and make a graph showing the relationship of material to melting time. (*Concepts 3A, 3B*) (Junior High)

K. EXPERIMENTING WITH A SAFE PESTICIDE

This activity is a good one to do after you have been studying the effects of chemical pesticides. It provides an opportunity for students to practice problem-solving skills and to investigate one alternative to chemical pesticides.

Students are to design an experiment to test the effectiveness of a natural pesticide—those that are produced by nature and do not remain in the environment (food chains). Although the list of natural pesticides is large you might have the class focus their experiment with garlic pesticides.

To make a garlic spray: Use 3 ounces chopped garlic bulbs (can use bought garlic bulbs, though organically grown ones are much better). Let them soak in 2 teaspoons (20cc) of mineral oil for 24 hours. Add 1 pint of water in which 1/2 ounce of oil-based soap (i.e., Palmolive) has been dissolved. Stir well. Strain the liquid through fine gauze and store in a glass container (it reacts with metal).

Have students design their experiment and present it to you for approval. Then try it. Have them write up their conclusions about how well the garlic pesticide works? Does it kill the pests or repel them?

Some of the variables they may wish to experiment with are: type of pest (usually should be an insect pest), the dilution of their pesticide (suggest they start with 1 part to 20 parts of water. Then go down to 1 part pesticide to 100 parts of water—so you use as little as possible), how the pesticide is applied, where it is applied, etc.

NOTE: Garlic will not harm animals or people. In fact, there is some indication that it may improve the health of the body. It is helpful in repelling fleas and mosquitoes as well. (*Concepts 1A, 1B, 2A, 3B*) (Junior High)

Social Studies

A. LIVING THINGS CHANGE

Have students bring a baby picture of themselves. Have students identify ways they have changed from when they were babies. Make a list. Put the pictures up without any names and see if others can guess who each baby picture is.

Thumbprints do not change. Make thumbprints. Study them. Use your prints to make pictures. List other ways you have not changed.

The environment changes. How do changes in the environment affect you? Make a collage or poster. Show changes in your environment.

Go outside and find changes in the environment. Show a friend. Is change good?
(*Concepts 1A, 5A*) (Primary)

B. A VISITOR FROM OUTER SPACE

Have students pretend they are visitors from another planet, seeing their community here on earth for the first time. Discuss the things they see that please them. Displease them? Need change. How could they be changed? Make a list of recommendations.

As a follow up, students could write and put on a play that shows what they would like their community to look like in the future—changing the things they dislike and maintaining the things they like. (*Concepts 5A, 5C*) (Primary)

C. DOES YOUR ENVIRONMENT AFFECT YOUR DAILY ACTIVITIES?

One way for students to find out how the environment affects their lives is for the students to keep a journal of all their activities for three typical days. (Hints on what to record: What they do after school or on weekends, what they eat, how they dress).

After the journals are made have students go through them and star the items that are affected by the environment. Number these items and on a separate sheet of paper, explain how the environment affected each of these activities.

Now, have students make a collage that shows things in your environment.

Have students write letters to others their own age who live in different environments. Ask about their daily activities. How do they differ from your activities? Could this be due to their environment? (*Concepts 3A, 3B, 5C*) (Intermediate)

D. WORLD POPULATION PROBLEMS

Where does the world's population live? This can be represented in a concrete fashion by this activity.

Arrange the desks as follows:

- 6 desks (Africa)
- 6 desks (Europe, including Russia)
- 5 desks (North America)
- 4 desks (Latin America)
- 4 desks (Asia)

Each desk represents 1/25th of the world's land surface. Now to make the world more realistic, add the following: Each person represents 1/25th of the world's population. Two students for North America, 14 for Asia, 2 for Africa, 5 for Europe (including Russia), 2 for Latin America.

Have the students take the chairs to the appropriate location on the earth and have them find a place to sit down. Discuss where they would rather live, where would they have the most room. What do they think will happen in 35 years, in 70 years?

What will all these people eat? Take 25 pieces of candy and divide them as follows: 1 each to Latin America and Africa, 8 each to Asia and Europe, and 7 for North America. This represents the food distribution and the amount each continent produces. Suppose the population doubles, does the food supply double? The population will double every 35 years. What will happen to the food supply in this time?

Discussions to extend the activity. What are some of the problems a population growth produces? Make a list of the resources people use. Can modern technology keep up with the population growth? Suggest inventions that will allow the earth to support more people. What will happen to waste disposal in future years if the population increases? (*Concepts 2A, 4A*) (Intermediate)

E. WHAT IS HAPPENING TO THE POPULATION IN YOUR AREA?

Where can you go to find out the growth or decrease in population in your area over the last 20 years? Make a graph of this pattern. What is happening to the population? How does this affect the area?

Next, conduct a survey of the people in your area. Ask how long they have been there. Find out if they intend to stay. Why did they come here? Bring the results back to class for a discussion.

Another group of students can study the history of your area. Talk to some people who have lived here for a long time. How has the area changed? What things are responsible for the changes? Report to the class.

After these reports have been made, discuss how a population change affects the resources in an area. Make a collage showing the resources people in your area need. Does your area have enough resources to support continued growth? Are other living things affected by changes in human population? (*Concept 2A*) (Junior High)

F. HOW DOES THE NEED FOR TRANSPORTATION AFFECT THE ENVIRONMENT?

As a class, list all the possible methods of transportation in your area. Then make a map of the area around your school showing:

- a. bike paths
- b. roadways
- c. mass transit (buses, trains)
- d. expressways
- e. sidewalks
- f. parking lots

(Add any others in your area)

Now list in order from largest to smallest which of the above takes up the most land.

Using a data card such as the following, compile a list of the ways each method of transportation listed affects the environment. For example: Does walking have any effect on air pollution? Water pollution? Does driving a car have any effect on air pollution?

DATA CARD ON TRANSPORTATION

Type of Transportation	Way It Affects the Environment					Is it Available in Your Community?
	Air	Water	Land	Noise	Litter	
Walking						
Bicycle						
Automobile						
Bus						
Plane						
Train						
Monorail						

When you've completed the above discuss the impact each type of transportation in your area has on the environment. Which ways help or do not hinder the environment and why? Which ways hinder the environment? How and why?

(Concepts 1A, 1B, 3A, 3B)

(Junior High)

G. SOLID WASTE IN OUR SCHOOL

Have your students collect the waste from several classrooms over a period of several days. For a representative sample you may want to collect material from several types of classes; i.e., art, shop, home economics, the teachers' lounge, English, etc. Once the material is collected have the students separate the trash into groupings of similar material.

Let the students create their own separation system. At this point a discussion on renewable and nonrenewable resources, biodegradable and nonbiodegradable materials and inorganic and organic substances can be conducted.

Once the materials have been sorted, charts can be prepared listing composition, original source or sources, and destination of the trash collected. This process should create considerable discussion on such topics as:

What is waste?

Where will all the waste go? Why?

What effect will this have on the environment?

Are there alternative solutions to waste disposal?

How could you cut down on the waste at your school? Home?

As a follow up to this activity have the class trace some of the throwaways through their complete manufacturing and distribution process. Discuss what all is involved in the process.

Visit the local waste disposal plant or have a representative of the local sanitation department come in and talk to the class about the local situation.

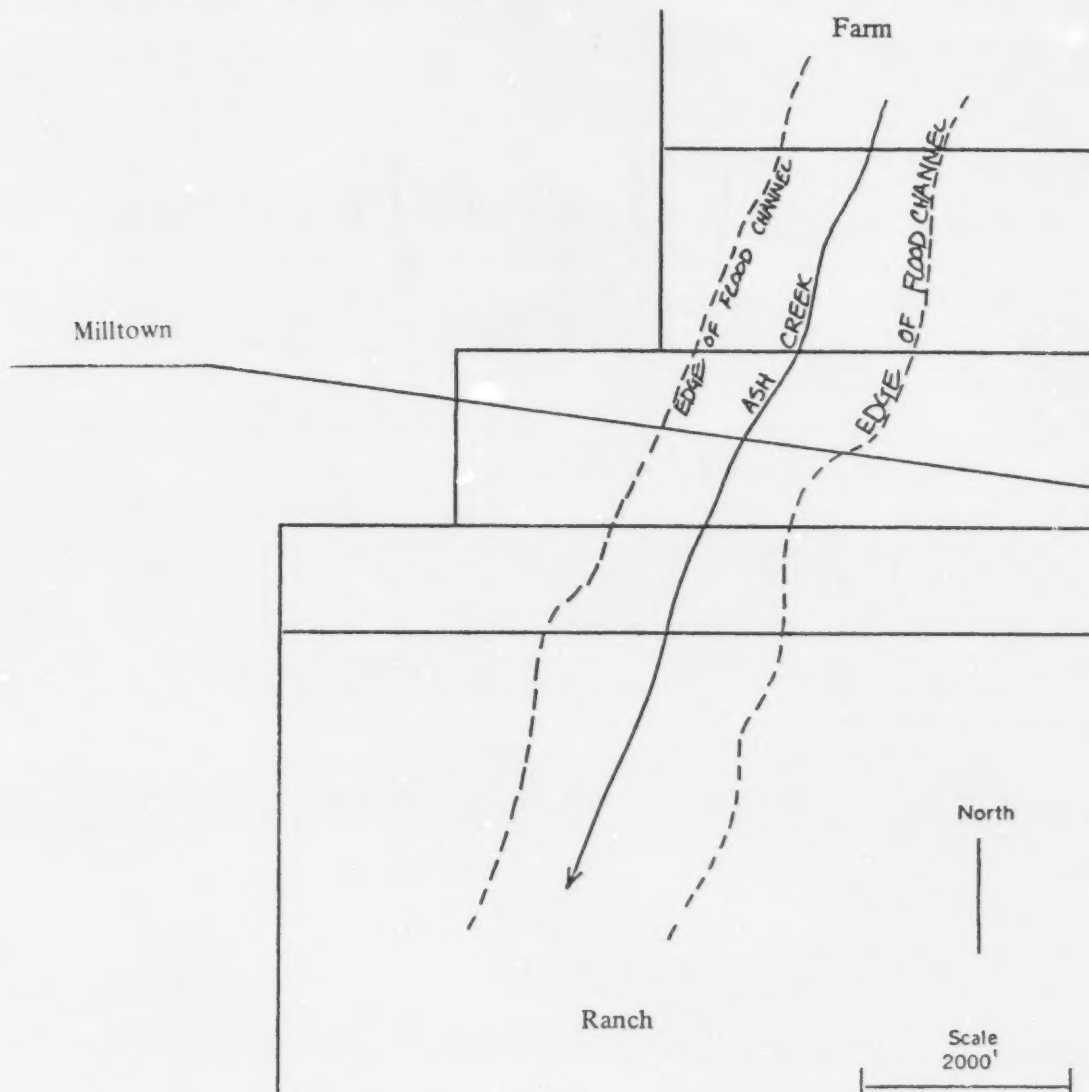
Investigate the possibility of setting up a recycling station on or near your school.

(Concepts 2B, 2C)

(Junior High)

H. DECISION AT ASH CREEK

Simulation and role playing exercise. Refer to the sketch below, which can be drawn on the blackboard or reproduced on letter-size sheets.



There are six pieces of deeded property crossing Ash Creek, one of which is a farm and one is a ranch. The other tracts are not used except for some occasional grazing or hunting. Ash Creek at this point is a small stream which is taken out below for irrigation. However, on occasion Ash Creek can be expected to flood; hydrologic surveys indicate that it has filled the channel to a depth of four feet and that it can be expected to do this about once in 50 years, although no one can remember seeing it in flood this deep. There are clumps of trees such as cottonwood, hackberry, mesquite, sycamore, juniper, and pinon.

Divide the class into five groups, each of which is to present a case to the Rock County Board of Supervisors. The Board has called a public meeting to hear discussion about the zoning plan which is to be completed for this part of the county within six months.

- Group
1. The landowners; some of them think they could sell lands along the creek for estate home development.
 2. The Enterprise real estate developers, who have an option to purchase some of the lands along the creek for "country estate" homes.
 3. The Rock County parks commission.
 4. The Milltown mayor and city council; Milltown is one mile away and is about to run out of solid waste disposal area.
 5. The Rock County planning and zoning commission.

Each group is allowed 15 minutes to prepare a presentation of what they want to see done with the land, including a large sketch. Then a spokesman for each group is allowed three minutes to present the case.

Just before the end of the 15-minute preparation time, the teacher should select one student from each group to form the County Board of Supervisors. After hearing all the statements, they will be allowed five minutes for discussion among themselves, then the chairman must propose a suggested recommendation for the zoning plan.

(Concepts 1A, 1B, 3A, 4A, 5B)

(Junior High)

Industrial Arts and Vocational

A. AT HOME IN THE ENVIRONMENT

Our homes are an important part of the environment. To help students begin to understand how the environment affects the home and the home affects the environment try the following:

Duplicate copies of the model home and have students cut them out and put them together. Have students color their model homes and then add an environment to the model by adding trees, shrubs, sidewalks, etc., to students' houses to create a community.

These models can then be used for follow-up discussions about such things as:

What things in the environment affect the house? Students will probably be able to see how wind and weather affect the home. Less obvious may be the ways plants and animals from the environment affect the home.

What things do you use in your house that affect the environment? Make a chart.

(Concepts 1A, 1B, 3A)

(Intermediate)

B. LAND FOR YOUR HOME

Assume a family of our class owns a house on a one-sixth acre lot. How many square feet of land per person is this (there are 43,560 square feet in an acre)?

The house measures 25 feet by 40 feet and the driveway is 20 feet by 30 feet. How much space does this leave for trees, gardens, lawn, and play area?

If the family doubled in size, how many square feet of land would there then be per person?

If an addition 12 feet by 30 feet is built onto the house, how much space will then be left for trees, garden, etc.?

Some questions to deal with as students are working on these problems might be:

Will these changes make a difference in the way the trees, garden, lawn, and play area are used?

Is it best to make plans about changes for the land and family activities?

Is this somewhat like anticipating population growth?

How might a house, housing complex, or city be designed to provide ample living space for each person yet not take away land for trees, lawn, garden, play area, etc. Design such a place (a visit to Solare's Archeology would tie in nicely with this effort). (*Concepts 3A, 4A*) (Intermediate)

C. DESIGNING A COMFORTABLE "HOME"

Students can learn a great deal about the principles of constructing homes that conserve energy by building their own "homes" out of cardboard boxes.

Each group of three students will need such materials as:

- 4-inch masking or sealing tape, and other "fixing" material
- extra long singed brass fasteners
- Exacto knife
- tin foil and/or other types of reflective-surfaced materials
- odd pieces of cardboard, all sizes
- paint, various colors
- cellophane, clear and colored
- window screen and/or other scrap screening materials
- newspaper, lots and lots
- paper mache paste

Have each group put together a structure large enough for one student to stand in or to lie down in. Put these "homes" outside. Consider: Are you comfortable inside it? Too warm? Too cold? What is the temperature inside the home? Outside? Is it the same temperature at the highest part of the structure as the lowest? What is affecting or causing the temperature inside the structure?

Now, have each group modify their home in order to control the temperature by doing such things as adding windows, putting some type of insulation inside or sun reflective or absorbent material or paint outside. Have students keep a record of what they did, the materials used, and the affect it had on the temperature.

Have students compare designs with one another. Can they see similarities in their designs with homes in the community, elsewhere? Do they think the design was for the same reason as yours? What conclusion can you make about insulation and design at this point in your study of energy conservation? (*Concepts 3A, 3B*) (Junior High)

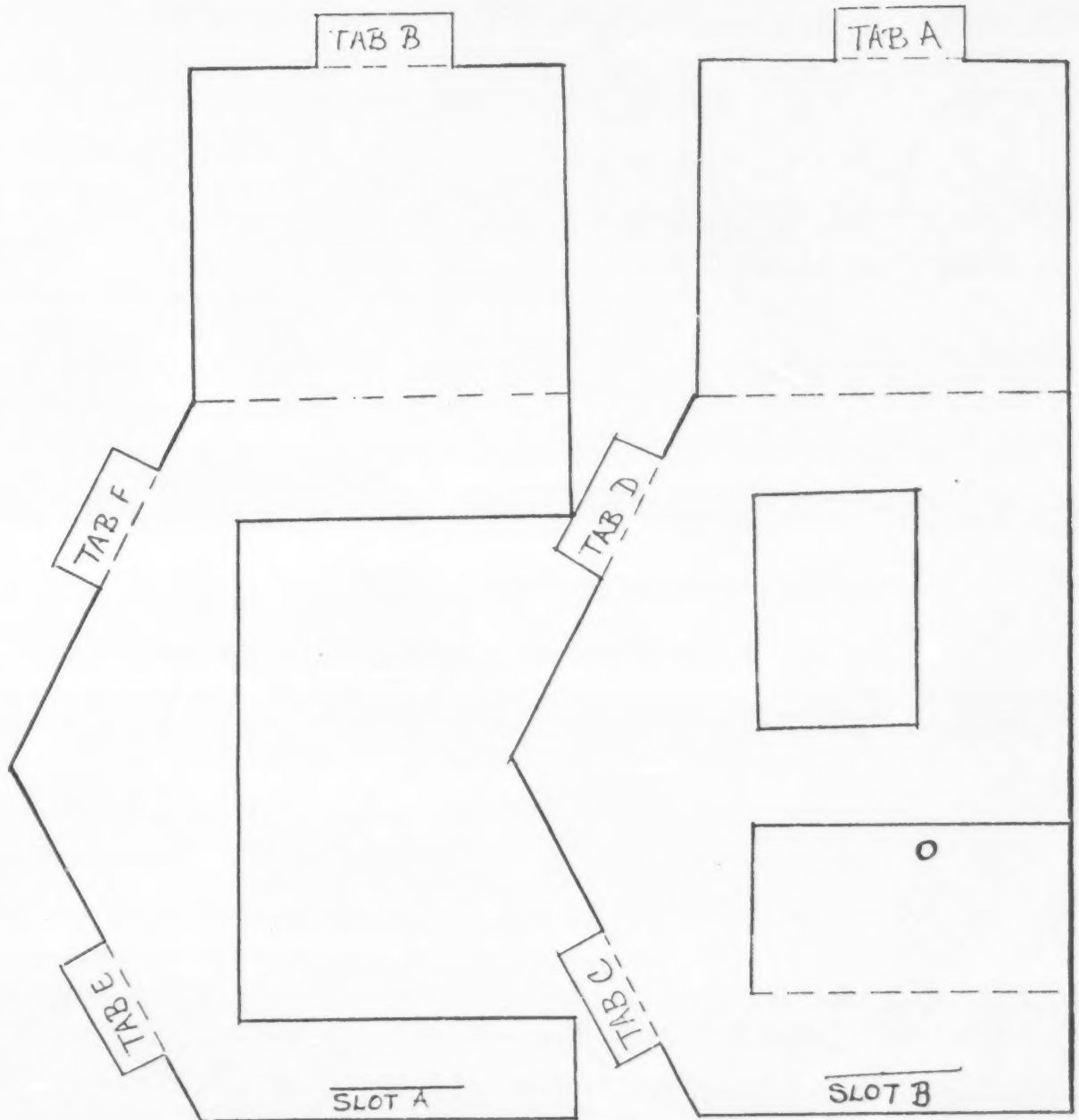
D. HOW AND WHY HAVE HOMES CHANGED?

Locate some older houses in your area. Contrast the style, size, and building materials in these homes with those of present-day houses. Has the environment changed in your area since these houses were built? What has caused the design of houses to change?

Talk to a local builder. Ask him how the construction of houses and apartments has changed in the last 20 years. Ask him what changes he predicts for the future. After you have completed your research, make a display to show how the design and construction of homes in your area has changed.

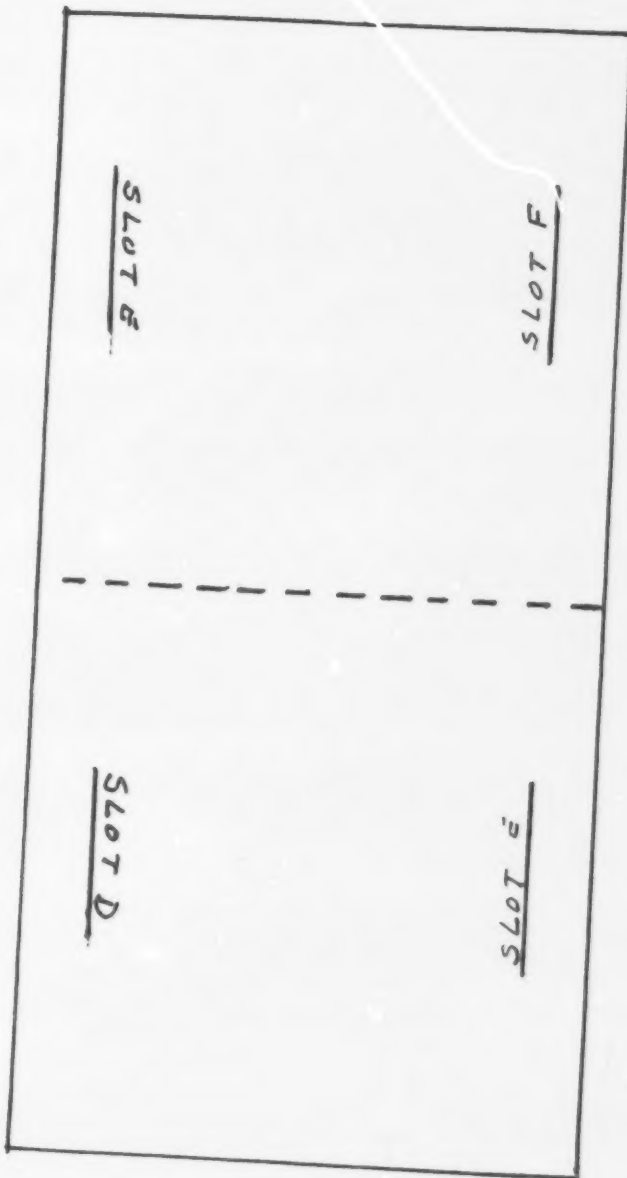
Suppose that your community became unlivable because of some change (pollution, nuclear fallout, drought, etc.). Try to design a house that could serve as a self-contained environment. Build a model. (*Concepts 1B, 3A, 3B*) (Junior High)

USE WITH INDUSTRIAL ARTS ACTIVITY NUMBER ONE.



MODEL HOUSE

Directions: Cut along solid lines. Fold along dotted lines. Match tabs and slots.



VOCABULARY

agriculturist (ag-ri-cul-tur-ist) – One who works the land in growing food.

carnivore (car-ni-vore) – One which eats animal flesh.

communal (com-mu-nal) – A group of people living/working together to provide lifes' needs.

ecosystem – The interaction of living organisms and nonliving factors in the environment.

exponentially – The related increase of one factor is dependent upon other factor(s).

finite (fi-nite) – Not limitable; having a definable limit.

herbicide (her-bi-cide) – A substance used to destroy plants.

nonrenewable – Something which cannot be regrown or reproduced (i.e., minerals like gold).

omnivore (om-niv-ore) – Refers to organisms that eat both plant and animals.

petrochemical – Derived from petroleum.

phreatophyte – Plants which obtain their water from the water table or the layer of soil just above it.

prey – An organism which is seized and eaten by another organism.

toxic – Acting like a poison.

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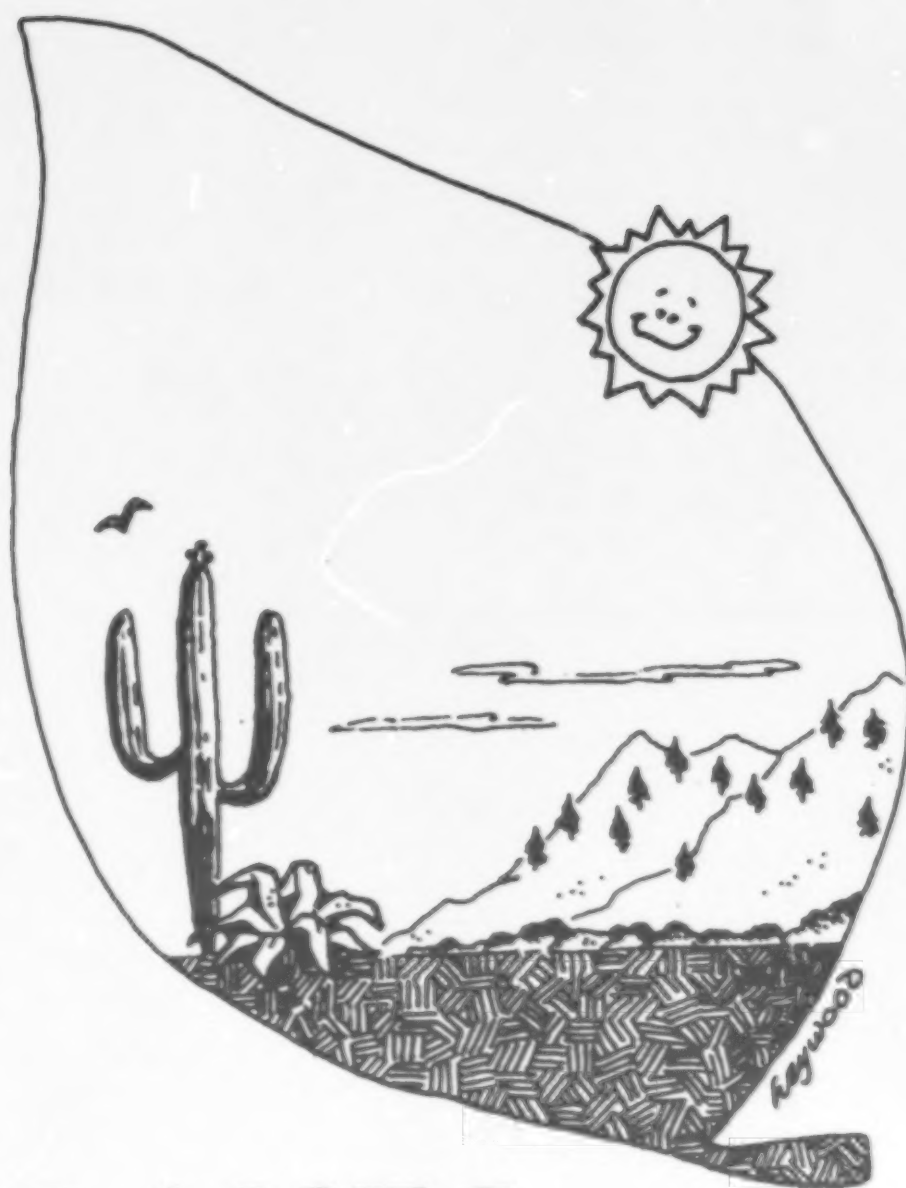
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PLANTS

PLANTS

Introduction:

All energy comes from the sun, and only green plants have the ability to convert the sun's energy to energy which can be used by other living things. The process of combining solar energy with water and dissolved nutrients from the soil is called photosynthesis. The product of photosynthesis is a plant sugar called glucose. When the plant is eaten by an insect and the insect is eaten by a bird, the energy in the glucose is transferred from plant to insect and from insect to bird. This transfer of energy is called a food chain and the plant is the primary producer.

In the plant world there is constant competition for water, sunlight, and soil nutrients. Whether the competition is most severe for water, nutrients, or for energy-giving sunlight depends upon the particular environment.

In the desert, the competition for limited water may be the most critical—in the dense forests on Escudilla Mountain there may be severe competition for sunlight. In communities of mixed plants, competition is usually less severe, because each kind of plant has special needs and adaptations to fill those needs. Where young pines are too dense, they will be stunted. When man wants his corn to grow tall and rich, he thins the young plants to reduce competition and assures the remaining plants an adequate supply of sunlight and water. He may supplement the water supply with irrigation and add fertilizer to the soil to increase available nutrients. In this way he can grow more and better corn than the land could have produced without his help.

Groups of plants adapt to the long-range environmental conditions to which they are exposed. These groups become plant communities, and life zones are defined by these plant communities. With the development of a plant community comes the development of an animal community to live within it—herbivores which eat those specific plants; carnivores which are adapted to capture those particular plant eaters; and decomposers which can recycle the dead plant and animal materials.

Man's early history demonstrated a dependence on plants. His communities developed only when he learned to plant, care for, and harvest a crop, rather than the simple gathering of wild plant foods. As he was able to create surplus food, the surplus was used as barter for his other needs. Even today, world populations are directly dependent on our abilities to manage the plant resources.

Plants are renewable resources and can, with care and knowledge, be managed to produce periodic crops for harvest. Plants such as corn, wheat, or strawberries can produce food crops annually, and forests can equally produce a harvestable crop for man, but over a longer period.

Plant communities are in constant change—they are not static. The process of such change is normally very slow. The environment must change to a degree unacceptable to the plants. Most such environmental changes are long term.

Environmental changes made by man are often too rapid for plants to be able to adapt, and plant communities are destroyed and replaced by new groups of plants. The newer communities are usually of less value to man, his livestock, and to wildlife. But using available knowledge, and having concern for this impact, man can be less destructive to the plant resources.

Plants supply the ecosystem with much more than food for other living things—they influence the composition of the atmosphere, protect soil, add oxygen to rivers, lakes, and oceans, and add their decomposing materials to both aquatic and terrestrial systems, further

enriching these environments. Plants affect the hydrologic cycle by recycling water through the process of transpiration. This water, as humidity, affects climate and is transported as rain to other areas.

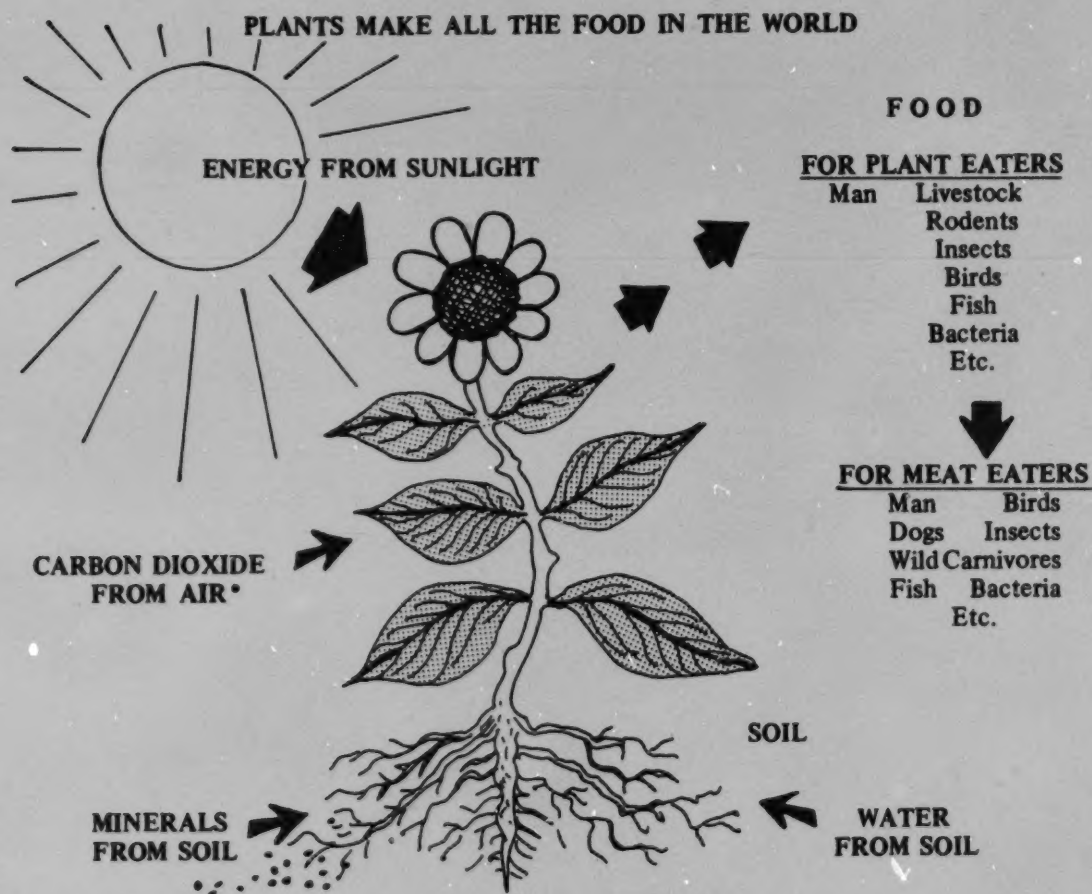
Plantlife is of great economic value to man—for food, shelter, chemicals, plastics, paper, and a myriad of other uses. But plants also have great aesthetic values—both in nature and as landscaping in modern cities. Even in primitive societies we find growing plants on doorsteps and on windowsills. The beauty of plants is only one in a long list of their values.

BASIC CONCEPT NO. 1 – Plants are the primary source of food for all living things.

Understandings:

A. Green plants produce food by a process called photosynthesis.

Cells in the green parts of plants contain small bodies, called chloroplasts. These chloroplasts capture energy from the sun, and combine this energy with water and dissolved minerals from the soil and carbon dioxide from the air. This process is called photosynthesis and produces a sugar called glucose. Plants containing this energy-packed glucose are called "primary producers." Plants do not get their food from the soil, only part of the materials from which to manufacture that food.



- B. All living things depend upon photosynthesis to change energy from the sun to energy which they can use.**

The energy (heat) to keep body temperatures constant, to power muscles, to allow man to speak and think, to make hearts beat comes from the sunlight that plants use to make their food. This energy is stored in the primary producers—the plants. The transferring of this energy from the primary producers to primary, secondary, and tertiary consumers and to decomposers is called a food chain.

When the mouse or rabbit (primary consumer) eats seeds or grass it absorbs the energy the plant created from sunlight, water, minerals, and CO_2 . When the mouse is eaten by the snake (a secondary consumer) and the snake is eaten by the hawk (a tertiary consumer), this energy is passed on step by step. And when the hawk dies, its body is reduced by decomposers—using the remaining energy to recycle the minerals back to the soil and the CO_2 back to the atmosphere. (See the carbon dioxide and carbon cycle diagrams.)

A group of food chains which overlap are called a food web—or the web of life.

CONCEPT NO. 2 – Plants compete for life requirements.

Understandings:

- A. Plants compete for light, space, nutrients, and water.**

Plants must compete with each other, as do animals, for all of their life needs. Desert plants are often carefully spaced so that their shallow root systems can gather all of the scarce rain that falls, and plants like the creosote apparently “defend” this territory with secretions which inhibit other plant growth within their sphere of influence. Forest trees compete for sunshine, and the faster-growing trees eventually crowd out their neighbors. Other shade-tolerant species, such as Douglas fir, can sprout and grow in the shade of an aspen grove—to grow and eventually overshadow the aspens and maples and to succeed them, changing a complex forest of diverse species into an almost solid forest of firs.

Root systems spread to gather the water and the dissolved mineral nutrients. These root systems intermingle, each rootlet competing for this water richness. A constant competition for nutrients, for energy-giving sunlight, and for water is a part of the plant world. Man has recognized this principle when he plants cotton or corn, fruit trees or watermelons; he has learned that each plant must have room to grow, sunlight available, and minerals and water to be gathered by its roots.

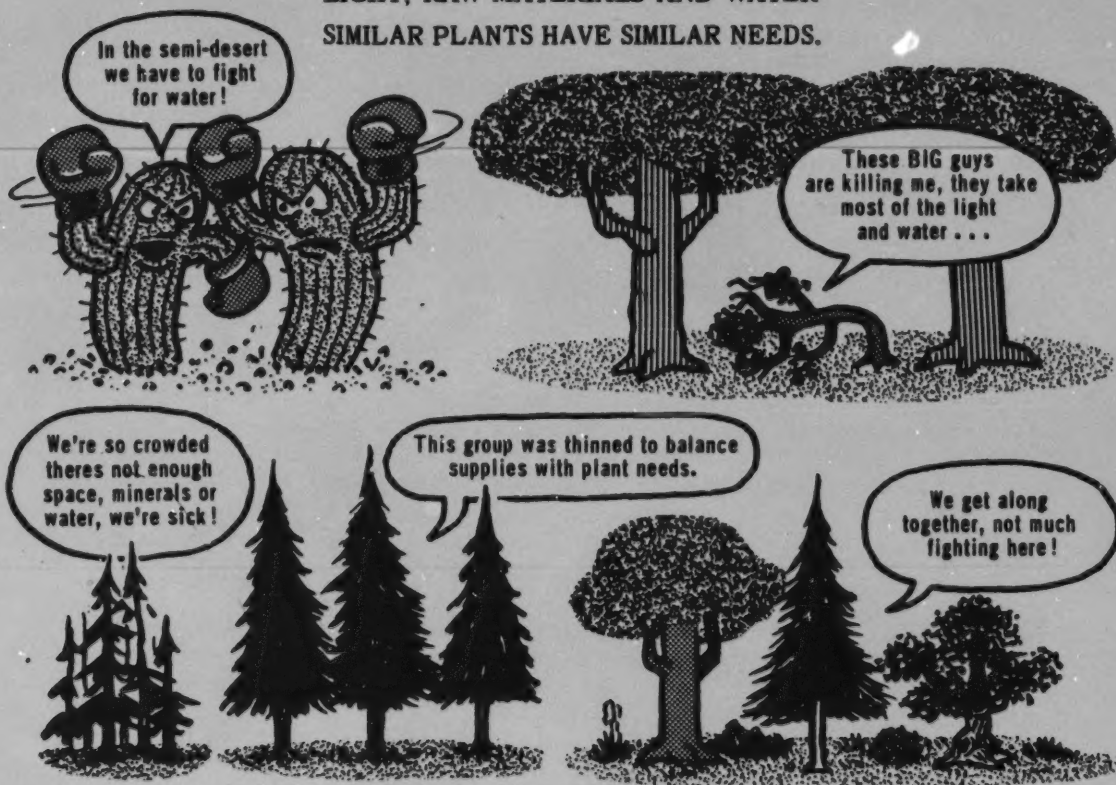
- B. Plant competition varies with the environment.**

The type of competition—whether for light, or water, or for scarce nutrients—depends upon the environment. In Arizona’s hot, dry deserts competition is mostly for water; in the higher mountains forest plants compete for light and water; in the chaparral there is competition for light, water, and mineral nutrients. On farms, man separates his plants so that there is little or no competition for sunlight, but the plants still must compete for water and nutrients. In most cases, the farmer uses irrigation and chemical fertilizers to reduce this competition. The farmer needs more plants than the natural systems could supply on the same piece of land.

C. Competition for life requirements is most intense when plant needs conflict.

Sometimes we see dense stands of young pines, firs, junipers, or aspens in our forests. These trees are usually small—stunted because there are not sufficient soil nutrients and/or water available for all. Without these raw materials the trees cannot manufacture food, and without food they cannot grow. Foresters thin such thickets and allow the remaining trees to prosper and grow.

**PLANTS COMPETE FOR GROWING SPACE,
LIGHT, RAW MATERIALS AND WATER
SIMILAR PLANTS HAVE SIMILAR NEEDS.**



Too many plants + not enough water or minerals = small unhealthy plants.

Plants in a mixed community have widely varying needs. They share available food, light, and water.

In a community of mixed plants this competition is not so severe because each species has certain adaptations which make its needs slightly different than those of its neighbors. This reduces competition and allows each to follow its own destiny. Man has begun to consider that the planting of a single-species crop over wide areas (monoculture) may be less efficient than a natural or mixed plant community.

CONCEPT NO. 3 – The type and amount of vegetation determines the type and amounts of animal life—including man.

Understandings:

A. Life zones are defined by plant communities.

Salt marshes are delineated by those plants capable of living in the marsh environment. The alpine tundra, above timberline on the San Francisco Peaks, is defined by stunted, miniature plants adapted to extreme cold, high winds, and a short growing season. Deserts can be defined by those plants capable of living with minimum rainfall and extreme temperatures.

These climax plant communities have adapted to the long-range environmental conditions to which they are exposed. As plants have adapted to their surroundings, so too have plant eaters and those who prey upon the plant eater. Whether the herbivore be insect, bird, reptile, or mammal, it has adapted to live in a certain plant community or communities. Some animals, like the coyote, the eagle, and the mountain lion live in a number of plant communities. And, whether the predator be bird or insect, mammal or reptile, he too is chained to the plant community by the food he seeks—one link leading to another. Such a community of plants and animals is called an ecosystem and the richness and variety of plant life in an ecosystem controls the numbers and variety of animal life.

B. Human communities and civilizations were most often based on plant resources.

Man was once a hunter and a gatherer. He killed other animals and gathered fruits, nuts, berries, and seeds for his food. He lived in the savannahs—grasslands interspersed with trees. The plant life dictated where he would live. When he learned to plant and cultivate seeds, he settled where grasses (wheat, corn, rye, oats, etc.) grew best. When he began to explore and to expand, he needed forest products. Some men moved to where there was timber for ships and fuel to smelt metals.

Wherever man expanded, he settled first where food plants were available or could be grown. His herds of domestic animals required grasslands and open forest for their grazing. Historically, we can see that man, like other animals, has almost always been controlled by plant varieties and plant numbers. Where he prospered, plants were varied and grew well; where he struggled, there was a limited quantity and quality of plant life. Even today, world populations are being and will continue to be controlled by man's ability to manage plant resources.

CONCEPT NO. 4 – Plants are a renewable resource.

Understandings:

A. Plant communities are not static, but are in constant change.

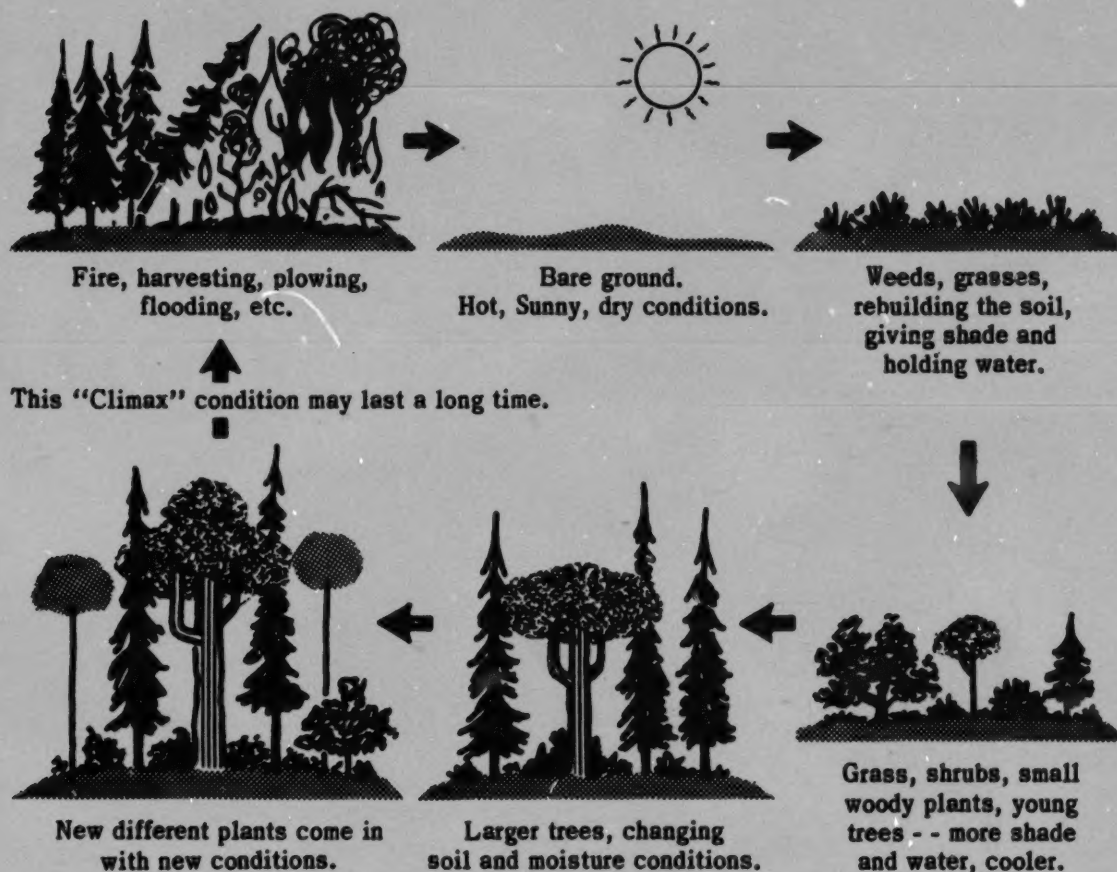
A "climax" plant community is the top rung in the ladder of plant succession. This situation is characterized by a relative stability of species and populations, but is not static. The continuing loss and replacement of individuals leaves the system open to change with the added influences of a changing environment.

A Ponderosa pine will be replaced by a Ponderosa pine, but only after the process of succession takes place to some degree. And, if some environmental factor has been added or subtracted, the Ponderosa may be replaced by another plant species—perhaps shrub or grass. Pines in Arizona require a minimum of about 15-20 inches of rainfall per year—a lessening annual rainfall might be such an environmental factor.

The process for change is normally very slow. For a climax plant community to change, the environment must change to a degree unacceptable to the plants. Most such natural changes occur very slowly. Fire, disease, logging, landslides, overgrazing, agricultural or urban development can destroy a climax community because the environmental change is too rapid for plant adaptation. Even after these natural or man-made catastrophies occur, there may be a process of plant succession and a recovery of the climax vegetation. But, if other environmental changes occur, such as loss of topsoil, soil temperature increases by exposure to the sun, water runoff instead of percolation, or soil disturbances, there will be a process of plant succession, but the ultimate, climax plant community may have been changed.

Here, in Arizona, desert grasslands have been changed to desert scrub and oak, grasslands and forest have become chaparral when these environmental changes were too rapid.

PLANT COMMUNITIES ARE CONSTANTLY CHANGING



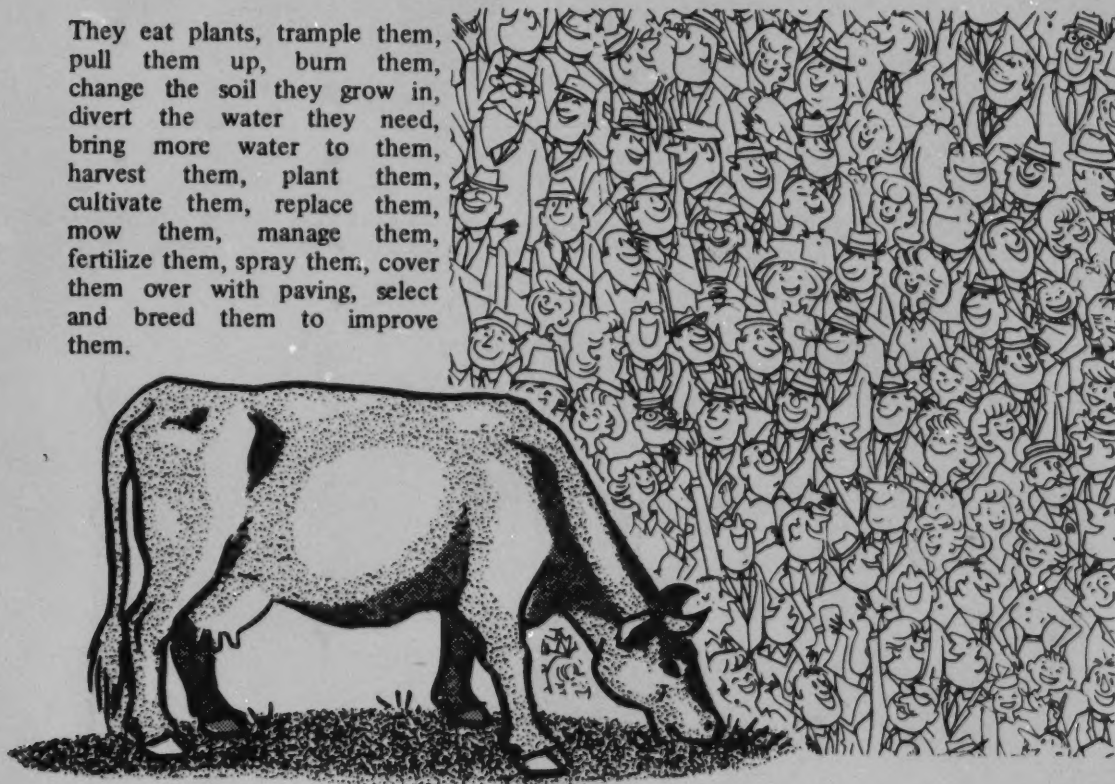
B. Animal populations may affect plant communities.

Native animal populations have only temporary effects upon plant communities. A Kaibab deer population (uninfluenced by modern man) increasing its numbers beyond the carrying capacity of the range crashes when it has eaten every bit of plant life within reach. And with deer numbers drastically reduced, the range recovers—slowly—ever so slowly. The deer population will recover much more quickly when food becomes plentiful again—perhaps decades later. There is a cycle of peaks and bottoms for both deer and vegetation, but there is little if any environmental change. The climax communities remain.

Domestic animals can have a greater negative effect upon plant communities. In the late 1890's and early 1900's there were an estimated five million cattle in Arizona. In 1975 there were only one-half million, and perhaps half of these were in feed lots, not on the range. The impact of five million cattle, plus sheep, goats, hogs, and horses was overwhelming. Historic grasslands, rich with life, became sterile deserts; other grasslands became chaparral and pinon-juniper forests. The Navajo Reservation, once mostly grassland, became largely a sandy waste. Soil erosion and compaction from ground-cover loss and trampling changed the environmental conditions, and the grassland climax communities disappeared.

In recent years there has been a degree of recovery. Reduction, limitations, and management of grazing have permitted an improvement—not to the original conditions—but to a condition substantially better than what was here 50 to 75 years ago. *The Changing Mile*, a book written and published by the University of Arizona Press, gives a graphic and dramatic look at some of these changes in its many photographs.

They eat plants, trample them, pull them up, burn them, change the soil they grow in, divert the water they need, bring more water to them, harvest them, plant them, cultivate them, replace them, mow them, manage them, fertilize them, spray them, cover them over with paving, select and breed them to improve them.



C. Plant resources can be managed.

Just as the farmer carefully manages the plants in his fields, wild, native plant communities can be managed. They can be managed to remain in their natural state or to increase their production of certain plants more desirable to man.

Forests are managed more and more to produce the most desirable trees for lumber and pulpwood production, and the development of "super trees" in forestry laboratories can potentially increase this yield by shortening the harvest cycle. Grassland ranges can be managed to produce more feed for livestock. These management practices vary from simple controls of grazing and logging to complex combinations of fertilization, pesticide applications, herbicidal controls of less desirable species, and the use of fungicides and rodenticides. The ultimate management is the production and maintenance of a "monoculture"—the growing of a single product. Cotton, corn, lettuce, or pure stands of Douglas fir trees are examples of a monoculture.

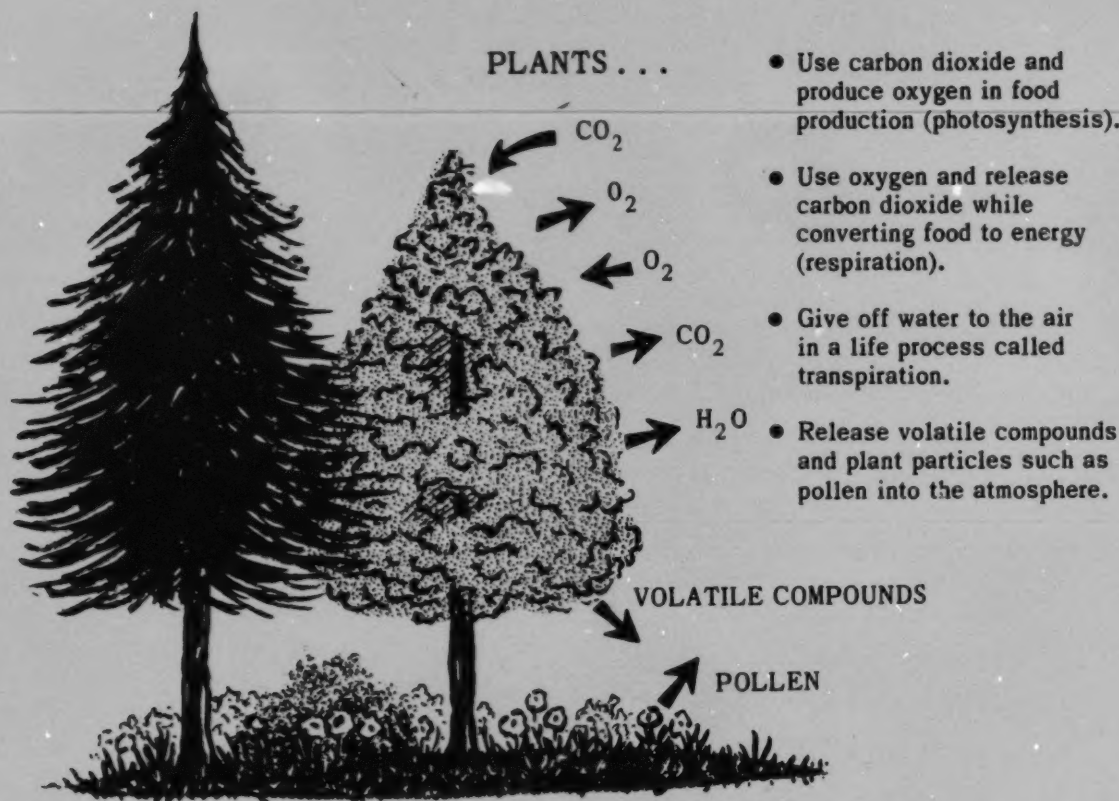
Monoculture increases the risk of loss to disease, insects, and animal damage. It also increases the competition between plants for, being alike, each has the same requirements. Under these conditions the crop has need of all of the farmer's chemical and mechanical tools. Many of these tools have side effects upon other plants and animals, and can pollute water and air.



Wise management of natural plant resources should consider not only the specific crop, but the effects of this manipulation upon other resources, such as wildlife. With a concept of sustained yield, multiple use, and rotation management the composition, conditions, and natural occurrences would be changed little from those in the natural climax growth.

CONCEPT NO. 5 — Plants influence the composition of the atmosphere; they affect the aquatic and terrestrial environments and hydrologic cycles.

PLANTS AFFECT THE ATMOSPHERE AROUND YOU



- Use carbon dioxide and produce oxygen in food production (photosynthesis).
- Use oxygen and release carbon dioxide while converting food to energy (respiration).
- Give off water to the air in a life process called transpiration.
- Release volatile compounds and plant particles such as pollen into the atmosphere.

SO . . . PLANTS AFFECT THE AIR YOU BREATHE!

Understandings:

- A. Plants affect the balance of oxygen and carbon dioxide and release volatile compounds and solid substances into the atmosphere.**

Essentially all free oxygen in our atmosphere was produced by plant photosynthesis. A major part of this oxygen is produced by minute plant life in the oceans—phytoplankton. Plants absorb CO₂ from the atmosphere as raw material from which to manufacture food during the same process. Though plants may be scarcer in certain parts of the world (some deserts and polar regions), this balancing effect is worldwide because of the winds that constantly stir the atmosphere.

Plants release various volatile (evaporable) compounds into the atmosphere. These compounds do not "pollute" the air, but may cause hazy conditions. The "piney" scent of a coniferous forest or the "creosote" odor found on an Arizona desert are examples. Plants also release pollen, spores, and other lightweight, solid substances into the air. These minute particles are significant in their impact on man's health and comfort. Allergies, hay fever, and other respiratory diseases can result from contact with these materials.

B. Plants affect the aquatic and terrestrial environments.

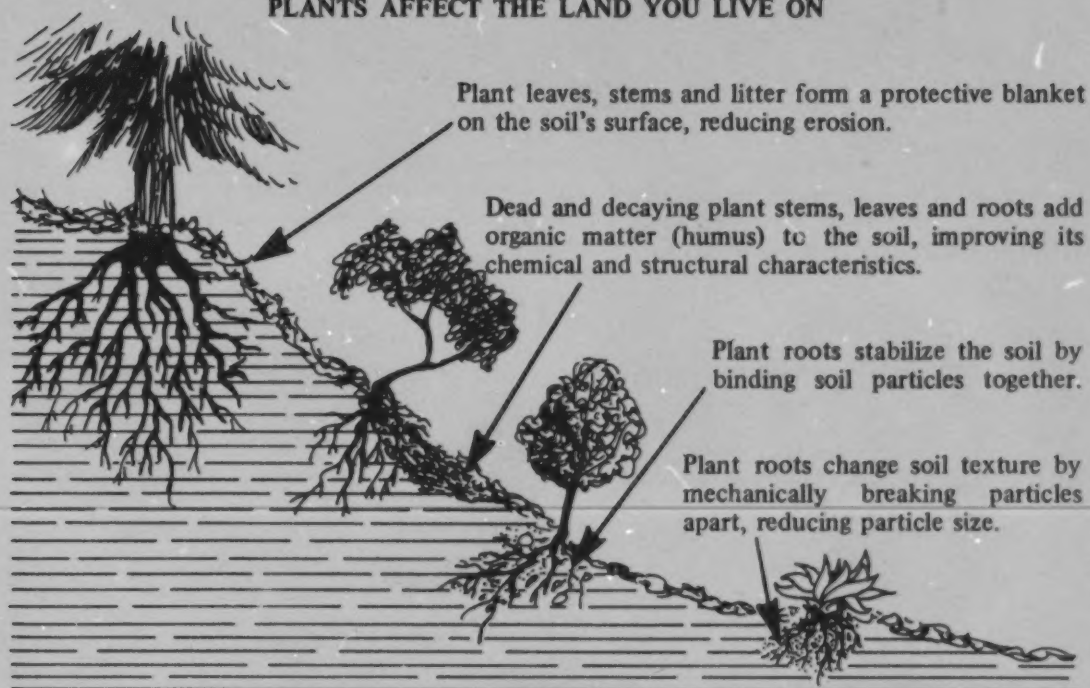
Plants, their roots, and plant litter (leaves, twigs, and bark) cover the ground in varying degrees. This material protects the surface of the earth from wind and from the erosive effects of falling rain and running water. It allows water to slowly percolate into the soil and through its layers, preventing quick runoff which may reach flood proportions. It provides an even runoff for springs and streams and the filtration through the soil provides clean water.

Aquatic plants add oxygen to water in streams, rivers, lakes, and oceans, making them habitable for fish and other animals which need oxygen. These same aquatic plants provide food and shelter for animals which live in these waters. Decomposing plants also add carbon and nutrients to the water, enriching it and clearing up suspended soil particles.

Plants affect the terrestrial environment by protecting the earth's surface from erosion, direct sunlight, and by slowing evaporation of soil water. Dead and decaying plant materials add organic matter (humus) to the soil, improving its chemical and structural characteristics. Plant roots may stabilize some soils by holding particles together but may also change other soil textures by breaking particles apart. Some plants add chemical elements to the soil which may change its chemical and structural nature.

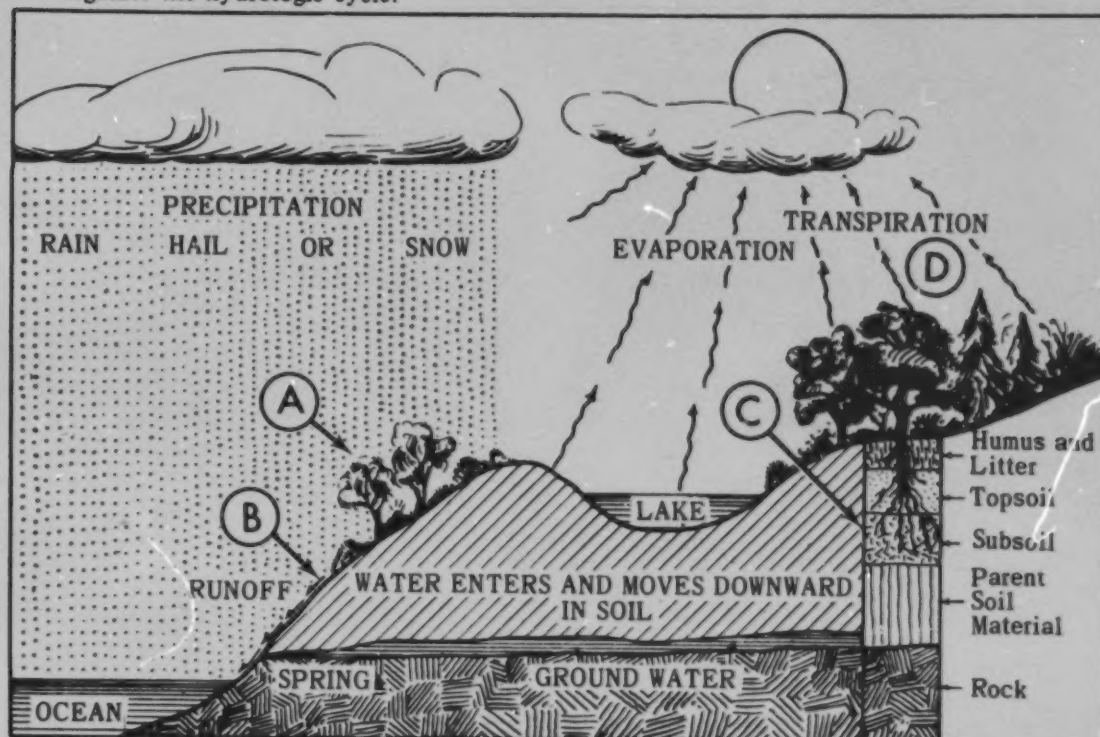


PLANTS AFFECT THE LAND YOU LIVE ON



C. Plants affect the hydrologic cycle.

Plants increase atmospheric water (humidity) by giving off water through the process of transpiration. Plant contributions to the slowing of runoff, to water percolation deep into soils, and to the protection of land surfaces which slows evaporation all affect the hydrologic cycle. The various actions between plants and free water serve to regulate the hydrologic cycle.

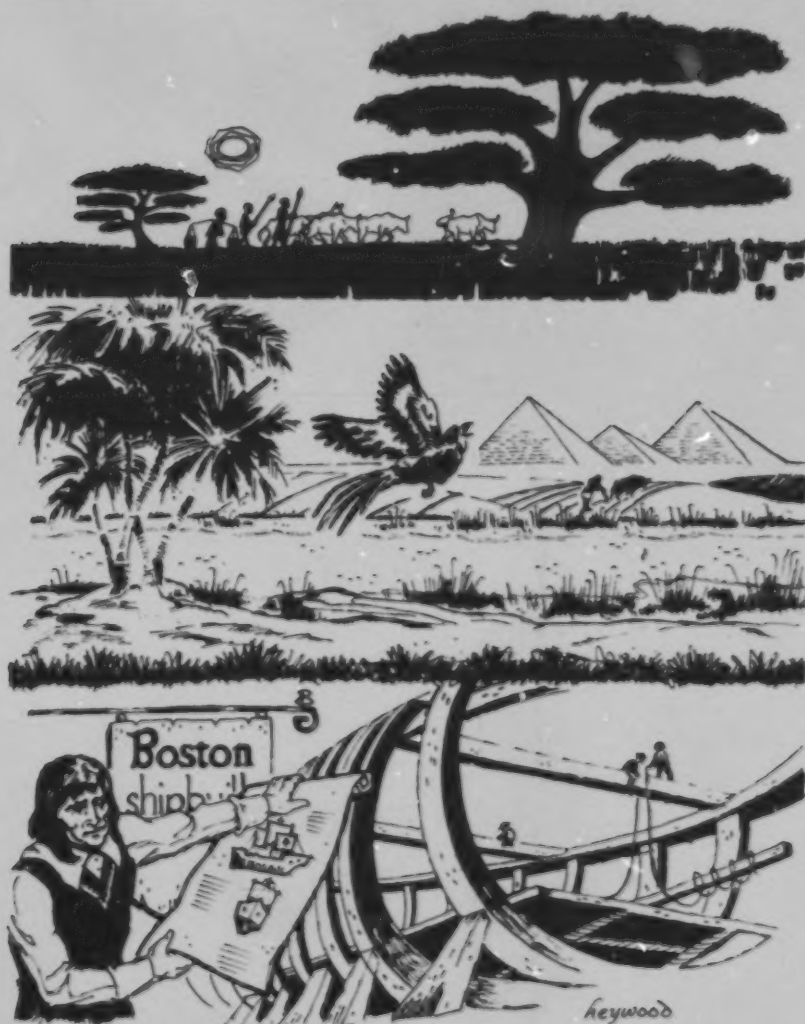


CONCEPT NO. 6 – Plant life is important to man.

Understandings:

A. Plants have economic values.

From earliest times, man has used plants for food, shelter, and warmth. He soon learned to use plant materials for medicines, for weapons such as bows, arrows, and spears, and for tepee poles. He learned the process of making charcoal to increase the heat of his fires and to enable him to crudely smelt copper, gold, and silver. There seemed no end to the uses he made of plants and yet today we use plants ever more widely. Today there are many uses of the forest: lumber, plywood, chemicals, plastics, medicines, paper in a variety of forms and for a multitude of purposes. Plants supply fiber for clothing, shelter as windbreaks; they clean and enrich water; prevent or reduce floods; supply food for us and our domestic animals; regenerate the soil . . . the list is endless—and to attempt to evaluate this resource in terms of dollars—impossible.



B. Plants have biological importance to man.

Plant photosynthesis is perhaps the most important biological process on earth; all living things depend upon the products of this process. The oxygen produced is necessary to all living things and the plant sugars transfer energy from the sun to the food chains of the world.

Sunlight is the source of energy for photosynthesis and smoke or dust in the air reduces the amount of sunlight a plant can receive. Reduction of sunlight reduces the products of photosynthesis and may have important effects upon all life—including life.

C. The aesthetic qualities of plant life are important to man.

Who amongst us is not uplifted by the beauty of a great forest, rolling grasslands, desert flowers, or scent of new-mown hay? Our art, music, and literature reflect this importance and the landscaping of our cities renews this commitment to the beauty of plants.

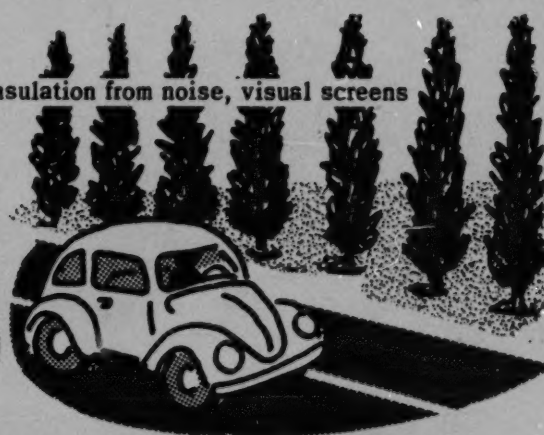
Plant masses are being utilized not only for the visual beauty but increasingly in buildings and along freeways to muffle and dampen sound. Plants, properly placed, can reduce this modern world's high decibel levels—and a quieter world is a more beautiful world.

PLANTS MAKE THE WORLD A BETTER, MORE PLEASANT PLACE FOR MAN TO LIVE IN. PLANTS GIVE US . . .

Natural beauty, spiritual uplift



Insulation from noise, visual screens



Materials for landscaping and windbreaks



Products for interior decoration

BASIC CONCEPT NO. 9 – Vegetation provides aesthetic benefits that are assuming increasingly greater significance to individuals and society.

Suggested Activity – Social Studies:

Someone has said "Beauty is in the eye of the beholder." Certainly individuals are different and have different interests and tastes.

Ask each student to bring a magazine picture of scenery that left a pleasant impression and have them explain why they liked the picture. See how many of these were influenced by vegetation. You may wish to follow up by showing color slides or large pictures of your own and let each pupil rate each picture's appeal (and *why*).

This activity can be expanded by describing how vegetation might be used to improve appearance, reduce dust, lessen noise, break the wind, provide shade.

Understandings:

- A. Plants provide natural beauty and spiritual uplift.
- B. Plants are often used to provide insulation from noisy highways, streets, factories, shopping centers.
- C. Plants are very effective visual screens and windbreaks when properly selected and planted. Even nature provides itself with natural windbreaks.
- D. Landscaping is almost impossible without plants which lend a natural beauty to our homes, schools, and factories. Have your students think about the outdoor world too. Is it landscaped? Explain.
- E. Plants and plant products are used for interior decorating.

SUGGESTIONS AND ACTIVITIES

Mathematics

A. TREE SHAPES, NATURAL AND UNNATURAL

Use a flannel board or cut shapes to introduce the basic triangle, square, and circle. Then, take your students on a short walk in or near the school yard and ask them to identify the shapes of various trees and bushes. Back in the classroom, students can (1) sketch trees that match the shapes and/or (2) tear or cut paper into the shapes they found.

VARIATIONS:

1. Take your students outside to a place where they can see trees clearly. Give them construction paper and ask each person to tear the shape of a tree's silhouette. Talk about tree shapes. Ask students to role-play these shapes. For example, stand tall with hands above your head for a poplar tree or spread out your arms for a maple tree. Use the tree silhouettes as a means of classification (they might be triangular or tall and slender, for instance). Ask your students to locate new trees and place them in one of the silhouette categories.
2. Take your class outside and help them find trees which have been altered by people (examples are hedges and trees trimmed so they won't touch power lines or obstruct views). Show students a simple tally method (e.g., ~~||||~~ or : :) to record the number of trees of each species which has been changed.
3. Take your class on a short walk and ask each student to draw a tree of one shape. Then students should exchange their pictures and try to match each one with its actual tree "model" on the walk back to school over the same route.

(Primary)

B. MATH EXERCISE

On a visit to a park (or in the school yard) during the fall you may involve all class members in numbers work by using directions such as these:

Take *three* steps forward, take *five* steps to the left.

Pick up *six* leaves (or twigs). See how you can arrange them in different *sets* (groups).

Arrange *seven* leaves (or twigs) in order of size with the *largest* one first and the *smallest* one last.

Find *three* leaves (or twigs) and arrange them so that the middle leaf is greater than ($>$) the one on its right and less than ($<$) the one on its left in size.

Return the objects used to where they were found and discuss with students why this is important. Have them look for partially decayed leaves, twigs, etc. Does this provide a clue?

(Primary)

C. HOW BIG IS YOUR TREE?

Discuss with your class the ways in which people in early times used their own physical forms (hand spans, for instance) to measure. Have students measure things in the classroom using different parts of their bodies: foot, hand span, arm span, length of a finger, paces. Then they should re-measure the same items using a standard metric or English ruler.

Talk about the accuracy of each type of measurement: "When John measured my desk he found it to be 10 hand spans, but when Joan measured it, she found it to be 11½ hand spans. Why did John and Joan get different measurements?"

Ask other students to measure the desk. If they don't grasp the connection between hand size and the number of hand spans needed, have those who count the same number of spans compare the size of their hands. Are they the same? Compare the number of spans students with large hands count to the number students with smaller hands count.

Ask, "How can we be sure the measurement of my desk is consistent?" Answer: Use the same person).

When you are sure students understand this concept, take them outside to measure three trees for height, diameter, and drip line. (Primary, Intermediate)

D. MAPPING OF URBAN OPEN SPACE

You will need a large map of your community which shows clearly its official boundaries or city limits and its parklands.

Assign students to use the map to calculate the total land area within your community's boundaries. This will require measuring its dimensions and using the map's scale to convert the figures to square miles or acres (1 square mile = 640 acres). Students should follow the same procedure to calculate the amount of community land set aside in established parks or open space for public use. From this, they should determine the percentage of the community area devoted to parks and open space.

Have your students write or visit the appropriate city or county offices to find out the historic and political reasons these parks and open space lands were allocated for public use. Was a percentage of the total community land set aside? Did public pressure play a part? Was zoning involved? Were the lands donated by private interests? Were they saved by chance? (Intermediate)

E. WILDFIRE!

Given the following table:

Number of Fires by Class of People Responsible

Class of People	1967		1968	
	No.	%	No.	%
Local Residents	889	41.2	1,199	50.7
Transients	159	7.4	185	7.8
Berrypickers, etc.	8	.4	2	.1
Fishermen	22	1.0	24	1.0
Hunters	71	3.3	42	1.8
Work Crews	44	2.0	49	2.1
Internal Combustion Engines	876	40.6	759	32.1
Miscellaneous	55	2.6	84	3.6
Nonman Caused	32	1.5	19	.8
TOTAL	2,156	100.0%	2,363	100.0%

Have students answer the following questions:

1. What single group was responsible for the most forest fires in 1967? In 1968?
2. What single factor was least responsible for forest fires in 1967? In 1968?
3. In which of the classes of people did the number of fires decrease from 1967 to 1968?
4. Compare the fires caused by the hunter class in 1967 and 1968.
 - (a) Was it an increase or a decrease?
 - (b) What percent of the original number is the increase or decrease?
5. What was the average number of fires caused by work crews for the two years 1967 and 1968?
6. The fires caused by local residents were how many times greater than the fires caused by transients in 1967 (to the nearest tenth)? (Answer: 5.6 [5.591]) In 1968? (Answer: 6.5 [6.481])
7. Construct a circle graph of 1968 data showing those people responsible for fires. Also include the nonhuman caused forest fires. (Intermediate)

F. PAPER CONSUMPTION

Ask your students to collect the newspaper accumulated in their homes during a period of seven days. At the end of the week, they are to weigh the newspaper and multiply the weight by 52 to determine the amount the family uses each year. Next, they are to calculate the amount of wood fiber used to produce the year's supply of newsprint (1000 pounds of wood = approximately 900 pounds of newsprint).

Students should answer these questions:

1. Based on the total circulation of your local newspaper(s), calculate the total tonnage of newsprint consumed in your community. What is the equivalent of this weight in solid wood?
2. In 1970, about 52.3 million tons of paper were consumed in the United States. The 1970 U. S. population was approximately 207.1 million. What was the average per capita paper consumption? In 1973, paper consumption was 61.7 million tons. Per capita consumption was 639 pounds. How many people were there in the U. S. in 1973?
3. In 1900, each American used an average of 58 pounds of paper per year. How many times more paper did each use in 1970 than in 1900? In 1973 than in 1900? In 1973 than in 1970?
(Junior High, High School)

G. A COMPARISON OF INSULATION EFFICIENCIES

Using the tables provided, ask your students to calculate the answers to these questions:

1. How many times more efficient is wood than aluminum? Than steel? Than concrete?
2. How many inches of concrete would be required to insulate as well as two inches of wood? How many inches of air space?
3. How many times less energy is required to produce one ton of wood than an equal amount of steel?
4. What is the ratio of energy required to produce equal amounts of aluminum to steel? (State in lowest terms.)
5. How many tons of wood could be produced using the same amount of energy as it takes to produce one ton of aluminum?

TABLE I

Thermal Properties of Various Building Materials,
Per Inch of Thickness

Material	Efficiency Percent
Wood	100.0
Air Space ¹	77.6
Cinder Block	22.4
Common Brick	16.0
Face Brick	8.9
Concrete (Sand and Gravel)	6.4
Stone (Lime or Sand)	6.4
Steel	.25
Aluminum	.06

¹Thermal properties are for air in a space and apply for air spaces ranging from 3/4 to 4 inches in thickness.

TABLE II

Energy Required to Manufacture Various Building Materials

Wood	—	453 kilowatt hours (kwh)/ton
Steel	—	3,780 kwh/ton
Aluminum	—	20,160 kwh/ton

(Junior High, High School)

H. PREDATOR PREY

Given the information provided, students should solve the problems posed.

Given:

One mountain lion can eat approximately 1,095 pounds of venison (deer meat) each year (in addition to rabbits, porcupines, and other small animals). The lion probably only consumes about 50 percent of each deer he kills; coyotes and other scavengers get the rest.

One deer eats approximately 3,650 pounds of vegetation/year in the form of grasses, herbs, brush, and tree leaves.

One square mile of deer habitat produces 800 pounds of vegetation acceptable as deer food/year. (NOTE: This varies depending on the region, condition of the range, and other factors.)

Problems:

1. What is the minimum number of square miles of habitat needed to support one deer?
2. If each deer averages 150 pounds in weight, how many deer are needed to feed one lion for one year?
3. How many square miles of deer-lion habitat are necessary for one lion to survive? (For the purpose of this problem, assume that one deer and one lion will provide continuation of the species, although of course, in reality, continuation would require many animals.)
4. Use a map of a region you are familiar with and outline an area large enough to serve as habitat for one lion. Ignore all roads, communities, and other developments which do not produce food for deer.
5. On the same map, again outline an area large enough to support one lion but this time take into account the producing acres. How much larger is the second area you outlined?
6. Notwithstanding all the development present in the United States today, there are more deer in this country now than there were when the first European settlers arrived. How do you explain this? What impact did the growth of the deer population have on other species of wildlife? (Junior High, High School)

Language Arts

A. LIVING LABELS

Take your class outside and station each student near a tree or other large, natural object. Each student is to serve as the object's "living label" to provide oral information about it when asked. Other class members (or guests from another class) will circulate to "read" each label.

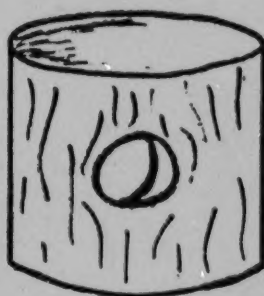
VARIATION:

Allow your students to select the natural objects they wish to be. Ask them to print on a piece of paper a list of 20 words which describe this object. They should attach the paper to their clothing. Other class members will try to guess their identities by reading the descriptive words. (Primary)

B. THE "TOUCHY-FEELY" BOX

Make a covered box (hatbox size would be fine). Cover and decorate appropriately. Make a round hole in the box so that students can reach into the box easily. For example:

Woodpecker
Hole



Simulated Log
(made from a
bulk ice cream
container)

Choose three quite different leaves to put in the box: one very smooth, one with jagged edges, one that is fuzzy. (Example: conifer needles, magnolia, flannel-leaf mullein).

Take the class to the place you found the leaves. Have students reach in; feel the leaves in the box. Then, when all have felt the leaves, ask them to find leaves that match the ones they felt. (Primary)

C. PLANT PERSONIFICATION

Ask your students to personify by demonstrating with large muscle activity the emotions felt by trees when there is:

- A gentle breeze
- A violent windstorm
- A gentle rain
- A hard rainstorm with thunder and lightning
- A snowstorm
- A forest fire
- A squirrel running up their trunks
- A bird nesting in their branches
- A person climbing them
- A person carving on their bark
- A person planting them
- A person harvesting them

VARIATION:

1. Read to your students, or have them create, a short story in which trees experience events similar to those listed in the first activity. Then, tell the students to substitute the appropriate dramatic interpretive movements each time the word or event occurs in the story. (Primary, Intermediate)

D. FOLKLORE DRAMATIZATION

Read aloud to your class a story related to the American outdoor heritage. Some examples are "Mother West Wind," "Johnny Appleseed," and "Paul Bunyan." (For other suggestions, see student section of Resources.) Help your students use one of the dramatic techniques, such as puppetry or role playing, to act out the story. Lead a class discussion on what these folk tales reveal about humankind's place in nature and how people behave toward it. (Intermediate)

E. MEMORY CIRCLE

This is a memory game. Arrange your students in a circle. The first player will tell something he has *observed* in a forest. ("I saw a trout hiding in a pool under some rocks.") The next player repeats the first statement and adds one of his own. The game continues around the circle until the list is too long to remember.

You may wish to specialize the game. Students could state what they *did to* the forest ("I caught a trout." "I burned wood in my campfire."), or what the forest did to or does for them ("I was warmed by the wood burning in my campfire." "I was refreshed by the long hike through the trees.")

List the students' statements on the blackboard and, after the game, ask the class to decide if each is beneficial, detrimental, or has little effect on the forest environment. Lead a discussion on:

1. What makes an action or observation beneficial to the forest?
2. How do we distinguish between a detrimental and a beneficial effect?
3. Were any of the actions detrimental to the forest but beneficial to people? Can we justify such actions? How? When?
4. Were any actions detrimental to people but beneficial to the forest? Can we justify these actions? How? When? (Intermediate)

F. I'D LIKE TO VISIT A PLACE WHERE . . .

Ask your students to write descriptions of their ideal recreation areas. Each student's essay should include details of the imaginary area's plants, animals, recreation facilities, geographic location, and geologic characteristics. Drawings or photographs may be used to illustrate the essay.

Share the essays in class and compare each students "ideal."

Discuss:

1. What characteristics are most often repeated?
2. Are there any unique characteristics?

3. Do any existing outdoor recreation areas meet your ideal criteria? Have you ever been to that area? If so, do you think the visit influenced your ideas on what an ideal area should contain? How?

VARIATION:

After students have completed their essays, ask them to study the accompanying list which describes the different types of outdoor recreation areas established by federal legislation. Then, each should decide which designation best fits his or her ideal area.

(Intermediate, Junior High)

G. TREE VERSE

This activity should be conducted outdoors, if possible.

Ask each student to brainstorm a list of 15 adjectives which could describe a tree or a forest. Repeat the exercise using verbs. Arrange words from these lists into a poem in the form of free verse, haiku, or cinquain.

Haiku, originated by the Japanese, consists of three lines of five, seven, and five syllables each. The emphasis is syllabic, not rhyming.

Example:

The snow covered tree
Sparkles in the soft moonlight
The wind rushes by

Cinquain is derived from the French and Spanish words for five. This form of poetry also is based on syllables but there are five lines. Each line has a mandatory purpose and number of syllables. These are (1) the title in two syllables, (2) description of the title in four syllables, (3) description of action in six syllables, (4) description of a feeling in eight syllables, and (5) another word for the title in two syllables.

Example:

Forests
Graceful, growing
Climb among the clouds
Joyfully stalking the sunset
Alive

(Junior High, High School)

H. A SIMPLER LIFE

Assign students to read the paperback book "Mountain Man" by T. Egerly. This is a story about a man known as Buckskin Bill who left "modern society" in the late 30's and built a life for himself in the primitive wilderness of the Snake River Canyon in Idaho. Buckskin Bill lives entirely off the land.

Ask students to write a composition comparing their life-styles with that of Buckskin Bill. Suggested guidelines for students to consider in their writing are: food gathering;

shelter; communication and the availability of news of the world; water supply; entertainment and recreation; work; cultural opportunities; reading; political activities; food consumed; cooking utensils; waste disposal and sewage facilities; skills required to survive; land area required to support oneself.

Share the compositions in class and lead a discussion on the possibilities of modern society reverting "back to nature."

Consider:

1. Could society as a whole emulate Buckskin Bill?
What would we gain and what would we sacrifice?
What might prohibit us from doing so?
2. How might less drastic changes in our life-styles contribute to a better environment?
3. What might some of these changes be? How could they help and what problems would they cause?
(Junior High, High School)

I. THE POWER OF LITERATURE

There is increasing public involvement in setting priorities and making decisions on environmental policies. The public attitude, or value system relating to nature influences, is influenced by literature. This activity shows how nature has been valued by three famous authors and how their views have affected contemporary values.

Assign your students to read "To Build a Fire" by Jack London.

Then discuss:

1. What is the setting of the story?
2. Who is the principal figure and what happens to him?
3. What is the significance of the protagonist's dog?
4. Why can't the fire be built?
5. What is London's view of nature as communicated in this story? (He sees it as an adversary which must be conquered before it conquers him.)
6. When London wrote this story, what was happening at the same time? (The Klondike Gold Rush.) How might this have influenced the author's attitude toward nature?

As a second example, students should read "The Big Two-Hearted River" by Ernest Hemingway and "Roughing It" by Mark Twain. Compare these stories with London's.

1. How does nature (the forest) help the principal character in Hemingway's story?
2. Does Hemingway's picture of nature differ from London's? If so, how?

3. If these authors had been given the responsibility of managing land, would they have done their jobs differently?

Ask each student to take the point of one of the authors and to write a short paragraph explaining the value of the forest to humankind. (High School)

J. ENVIRONMENTAL ADVERTISEMENTS

Ask your students to find and bring to class two newspaper or magazine advertisements dealing with the same issue, one prepared by a forest industry group and one by a citizens' conservation organization. In class, students should evaluate each advertisement on (1) its emotional appeal, (2) its factual basis, (3) the value system it conveys, (4) the credibility of the arguments stated, (5) the use of propaganda techniques to help communicate the desired message or objective of the advertisement.

After students have written their evaluations, discuss:

1. To which advertisements do you give the most credence? Why?
2. Of two opposing advertisements, do you agree entirely with either? If not, why? If so, do you disagree with all the arguments presented in the other ad?
3. How are the ads similar and how do they differ?
4. What seems to be the purpose behind each group's ad? For example, is it to provide information, to justify a practice, to counter charges?

(Junior High, High School)

K. CARTOONS AND HEADLINES

Ask students to write "not-likely-to-happen-headlines" with an accompanying lead paragraph relating to the origin or use of some forest resource or issue. Examples are:

Lumber Harvested in National Parks

Wilderness Organizations Want Grand Canyon for Landfill

Timber Interests Advocate Raising Home Interest Rates

Allowable Cut Can Exceed Growth Indefinitely, Says Genetic Expert

Decay Organisms Unnecessary, Says Forest Ecologist

Discuss why each headline is unlikely. What conditions would have to occur before the headlines would be probable? Are any of these conditions likely to happen in the future? (High School)

Fine Arts

A. THE ARTIST AS A RECORDER OF REALITY

As a class, view pictures and/or photographs done by various artists depicting forest scenes. Discuss these, using such questions as:

1. If you were here in the picture, what might you hear? See? Smell? Feel?
2. What kind of place is this?
3. What colors do you see? How do they make you feel?
4. What could you do if you were there?
5. Where is your favorite place in the picture? (Primary)

B. PATTERNS IN NATURE

Take the students on a nature walk through a field or wooded area or the school grounds. Let students use pencil, paper, and crayons to record colors, arrangements, patterns, and designs of objects they observe. Investigate and compare these recorded observations, and look for repetition in nature. Why are these colors, arrangements, patterns, or designs repeated? Are they of any value to the object? Sample observations may include:

- Green coloring
- Flat leaves
- Tree branching patterns
- Circular patterns in flowers
- Color in flowers

C. LEAF PRINTS

Art projects can be used to help students develop the ability to classify objects. These activities provide easy introductions to the classification of leaf shapes.

1. *Spatter prints*

Ask your students to bring a variety of leaves to school or take the class on a walk to pick up leaves from the ground.

Materials needed:

- Metal wire screen (plastic or nylon screen with net also will work) 9 inches x 12 inches
- Toothbrush
- Straight pins
- Tempera paint
- Paper 8½ inches x 11 inches

Procedure:

Place a leaf on a sheet of paper and secure with pins. Place screen over leaf and paint across the screen.

As the project progresses, talk with each student about the differences he sees in the shapes of the leaves being used. As a follow-up, have the class look at all the prints and group together those with leaves of similar shapes. The prints also may be used to identify leaves outdoors. (Intermediate)

D. NATURAL ART

Help your students make a large color wheel, including browns, tans, and grays. Take the class on a short hike and ask the students to try to match objects they see with sections of the color wheel.

VARIATIONS:

1. Collect natural materials in a variety of colors and display them on a large bulletin board. If the students gather these during a class walk, it offers an opportunity to discuss conservation practices in collecting. Help students develop some classifications (such as natural, man-made, beautiful, ugly); classify the materials and explain why they placed each material in a certain category.
2. Students may use natural materials to create a mobile, collage, or scene.
3. Students may make crayon rubbings or charcoal rubbings (with burnt wood) using various textured natural materials such as bark, leaves, seeds, rocks, and sand.
4. Students may use leaves, dried seeds, ferns, and other natural materials to create forest creatures (real or imaginary) and then name them.
5. Students may glue acorns, nuts, cones, and similar materials together to make "seed" people or animals.



Acorn

Pine Cone

Maple Seeds

6. Students may use natural materials dipped in paint to make designs. For instance, roll paint-covered pinecones over paper to make prints.
7. Students may make a design on dark paper. First apply glue to paper, then shake on sand, soil, or crushed materials. Allow to dry completely before displaying.

E. PLANT DYES

Collect any or all of the plant materials listed below and make plant dyes. Allow the students to use these dyes to paint pictures of the things they saw while they collected the materials or to dye cloth for later use in art projects.

Make use of the collecting time to teach conservation practices in collecting. The materials collected should not noticeably change the environment of the area in which they were found.

COLOR	PLANT SOURCE
Blue-violet	Cherry roots
Purple	Elderberries
Reddish-purple	Pokeweed berries
Red-pink	Dandelion roots, cherries, strawberries, red raspberries, cardinal flowers, sorrel roots and bark
Violet	Grapes
Blue	Blueberries (boiled)
Dark brown	Walnut husks (boiled)
Reddish brown	Buckeye husks
Yellow	Goldenrod (boiled), willow leaves, marsh marigolds, ash—inner bark, St. Johnswort flowers (boiled), onion skin, ragweed, burdock
Rose tan	Aspen, willow bark
Green	Plantain leaves and roots (boiled)
	nettle roots, stalk, leaves,
Salmon	Cherry bark
Black	Walnut husks, sumac leaves

Procedure:

Chop all materials. Boil each separately. Strain. Add alum — 1/4 to 1/2 teaspoon to 2 cups of liquid. If curdling occurs, add cream of tartar in the same amount.

Use these materials to paint with or to dye cloth. Wool is the best material to dye. It should be simmered in the dye for about 30 minutes. Wring out dyed material. Wash repeatedly in baths of cold water; repeat until water is clear.

F. NATURAL MATERIALS ART

Have your students, working in small groups, create collages using only the materials they can obtain from a natural environment. Or, take your students to a natural area; provide drawing paper, and ask them to create a picture using only those colors they can obtain from natural sources there. They might use charcoal from burned wood to produce black; soil or rocks for brown, gray or red; leaves for green; berries for purple.

You may wish to "fix" the collages or pictures with lacquer or hair spray but, first, ask students if they consider adding the preservative "natural," especially if an aerosol can is to be used.

After the art works are finished, hold a class discussion to help students analyze the impact of their art lesson on the environment.

Suggested questions are:

1. What did you exploit to create your art work?
2. If all the art classes used the same outdoor site, would it lose its naturalness?
3. How could you have created your art with less impact on the environment?
4. How much did your project change the environment?
5. Was the change for better or for worse? What criteria are you using to judge the impact as good or bad?
6. Will this environment recover from the changes you made? Could the recovery process be speeded up, slowed down, or stopped? How?
7. Do you think your art work was a fair trade-off for the natural elements you used up? Would someone else feel the same as you?

G. SYLVAN SERENADE

Students will present a band, orchestra, or choral concert using music which shows how different composers have interpreted the natural environment.

Examples of music which could be on the program are "The Falling Leaves" by Benson; "Tall Cedars" by Osterling; and "Green Leaves of Summer" by Tiomkin and Herfurth. The concert might be devoted entirely to classical selections or to contemporary selections or it might include both.

Ask your students to research the music selected and to write program notes. The notes could be in several forms. Students may choose to write short poems or paragraphs describing the environment which inspired the composition and the composer's attitude toward it as interpreted through his music. Or they may write short descriptions of the emotions evoked in themselves by the music.

VARIATION:

Substitute natural sounds heard in the forest at appropriate places in the compositions chosen. Ask students to create new arrangements for the music selected or to compose a new piece using natural sounds instead of traditional musical instruments.

H. THE CHANGING FOREST

Either as an individual or as a small group project, ask your students to plan and produce multimedia presentations which demonstrate that the forest is a dynamic community.

The choice of media and format should be made by the students. Slides, film, posters, photographs, and tape recordings are examples of communication tools which could be used.

(So that students will more fully understand the term "dynamic," they should be encouraged to read or view some of the references cited in Resources.)

Productions will be presented in class and be evaluated by the student audience. Some criteria for evaluation are:

1. How effectively the message was communicated.
2. The technical clarity of the medium used to transmit and explain the message.
3. The scientific accuracy of the script or pictures.
4. The appropriateness of the medium to the message.

Science

A. GROWTH GRAPH

Show students how to plant marigold, bean, or radish seeds. As plants begin to grow, students should measure their heights with construction paper strips, rulers, or number lines.

The measurement data then can be transferred onto graph paper to illustrate the growth of the plant. Measurement data can be collected daily, weekly, and monthly. Students can make colorful graphs by gluing strips of construction paper on the chart.
(Primary)

B. BIRD 'N WORMS

Introduce students to the meaning of the words "camouflage" and "protective coloration."

Obtain colored (green, red, blue, yellow, brown) pipe cleaners from a local store or craft shop. Cut each cleaner into three pieces. Have the students twist or bend these into worms.

Scatter a known number of pipe cleaners of each color over an area on the playground, in the grass, on the parking lot, or on bare soil. Give each student the name of a bird to impersonate. Suggestions are: robin, thrush, meadowlark, bluebird, flicker, and crow.

Then, one at a time, call out the names of these birds. As each species is called, direct that student to "fly" out over the area where the "worms" were scattered and pick up the first worm which catches the "bird's" eye.

As students return from their flights, have them lay out their worms in the order picked up on a large piece of white butcher paper. Repeat until all students have made at least one "flight."

Help students consider the sequence of the "worms" captured and placed on the paper. Discuss with them any trends or patterns that occur. For example, if the worms were scattered on grass, one would expect the green "worms" to be picked up toward the end of the game rather than in early flights. (Primary)

C. SUNLIGHT AND SHADES OF GREEN

Choose a small shrub or tree with leaves which are easily reached. Have students cut out several circles or squares of cardboard, each just large enough to make a good-sized "patch" on a leaf of the shrub or tree.

Show students how to use paper clips to attach a cardboard circle or square to each of several leaves. After four days, remove the pieces of cardboard and have the class observe the lighter-colored spot on each leaf where the cardboard deprived the leaf of light.

Discuss:

What might have caused the spot? Have any of you ever seen this happen before? What might have caused it then? (Some students may have observed this phenomenon before when moving objects that had been placed on growing grass.)

Why aren't plants that live in the shade yellow-green? Compare two leaves from the same species of plant, one from a plant growing in full sunlight and the second from a plant growing in the shade. Which one is a deeper green? Does this agree with your experiment with the cards? (Intermediate)

D. DID YOU EVER EAT A PINE TREE?

Lead your class in a brainstorm session to produce a list of food people eat. Don't forget to include water! Then discuss:

1. Which foods come from plants?
2. Which foods come from animals?
3. What do the animals eat? Where does the animal food come from?

Then, help your students create a mural or bulletin-board display illustrating sources of food. Link the sources, for instance beef—grass, to form a food web.

VARIATION:

Take your students to a grocery store to look for and then list items which are food products from forest plants such as trees and berries. Another way to do this is to ask students to bring from home labels off of packages and cans which contained foods from the forest. Use this list, or the labels, as part of the mural or bulletin board.

Discuss:

1. Which food items are used to produce other food items? For example, corn is feed to cattle.
2. What do most of the animals we eat, eat? (Answer: Plants.)
3. Where do the plants get their food? (Answer: They make it from the soil and the sun.)
(Intermediate, Junior High)

E. PLANT GROWTH AND TEMPERATURE

Late in winter, just before local outdoor plants usually begin to blossom, ask your students to select a bush or tree near your school. They are to place an India ink or string marker near the terminal bud or bud scar and measure the distance from the marker to the end of the branch.

Students will record the air temperature and measure the twig for growth every two or three days at the same time of day. After an extended period of time, they should graph the data collected with temperature on the vertical axis of the graph and growth on the horizontal axis.

Discuss:

1. What is the relationship between air temperature and the amount of plant growth?
2. What variables may have influenced results, besides air temperature? (Soil moisture, cloud cover, and . . . ?) How could you conduct further investigations to determine the effect of each of these factors?

VARIATION:

The graph may be done as a bulletin board with separate groups of students keeping track of specific bushes or trees so that comparisons may be made. (Junior High)

F. SOW BUGS 'N SOIL

Sow bugs are crustaceans that live in cool, dark, moist places in forest ecosystems. This activity shows that sow bugs contribute to the forest litter by digesting leaves and by

producing litter of their own in the form of droppings and their own dead bodies. It also can be used to show that sow bugs have a preference for certain components of forest litter.

During an autumn or spring, students should be able to collect a large number of sow bugs by looking under logs, stones, and branch and leaf litter in wooded areas. As students gather the sow bugs, have them also collect several leaves of different kinds (oak, maple, alder, birch, fir, pine, grass) and place each kind in a closed container with several (eight to ten) sow bugs. At the same time, they also should establish control containers which have plant material but no sow bugs.

NOTE: Plastic bags filled with air make excellent containers. There should be plenty of moisture in each container; if plastic bags are used, the air supply may need to be renewed daily. Do not keep containers in the direct sun.

Each student is to keep a record of changes in the number and size of sow bugs; number of days it takes to completely eat the leaves; types of leaves used, and any other pertinent information. After several days of observation and data collection, compile the class's data and pose some of these questions:

1. Do sow bugs seem to have distinct food preferences? In what kind of forest would you expect to find the greatest number of sow bugs?
2. How do the containers with sow bugs differ from those without?
3. What function do the sow bugs serve?
4. In what ways do the sow bugs contribute to the development of organic matter in the forest litter?
5. In what other ways do the sow bugs contribute to the forest ecosystem? (They serve as food for other animals.)
(Intermediate, Junior High)

G. CHRISTMAS TREES—AFTER CHRISTMAS

Ask your students to:

1. Obtain a discarded Christmas tree whose place of origin is known and determine the year in which the tree was planted.
2. Obtain the yearly rainfall for each year the tree was growing for the area in which the tree was grown.
3. Measure the distance between the internodes (branch whorls) to determine the tree's annual height growth and plot height growth against rainfall on a graph.
4. Cut a clean cross section near the base of the tree. Measure the tree's annual lateral (diameter) growth. Plot diameter growth against rainfall on a second graph. As data is plotted, identify the year that each dot represents.
5. Calculate the diameter the tree would have been if the largest amount of rainfall it received in one year had occurred each year of its life. What is the percentage

of increase over its actual size? Do the same with height. Are tree diameter-growth and height-growth influenced by yearly rainfall? What is the relationship? If this year we receive an unusually heavy rainfall, when would you expect a large diameter growth to occur? A large height growth? (Do diameter and height growth respond the same to a given year's rainfall?) (Junior High)

H. MAKE YOUR OWN PAPER

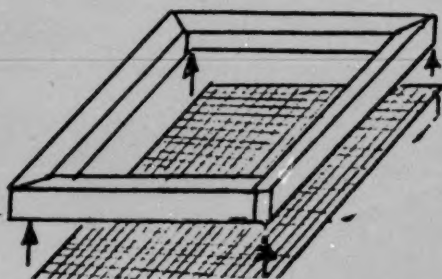
Students will design and build a wooden deckle (see illustration) with a removable screen to make paper of the desired size. When the deckle is finished, the students are to obtain several kinds of discarded materials they can use to make recycled paper. The materials can include such things as old newsprint, cardboard cartons, and similar items.

Procedure:

1. Tear sheets of paper or cardboard into small pieces less than 2 inches in diameter and put the pieces into a large basin.
2. Add water and laundry starch in proportions of 1 tablespoon of starch per cup of water to the torn paper and beat with an egg beater until the pulp is the consistency of a very light gravy.
3. Dip the deckle sidewise into the pulp mixture until the screen is completely coated with a light layer of pulp.
4. Remove the screen and wet sheet of pulp from the deckle and place between two pieces of blotting paper.
5. Press out the excess water with a rolling pin or pipe and allow to dry.
6. Peel the "recycled paper" from the blotting paper and trim to size.

Students should compare the paper produced from different kinds of pulp materials. Which sheet of paper is the strongest? Which is more water resistant? What other comparisons can you make?

SAMPLE DECKLE DESIGN



Corners may be
joined at 45°

Or flush at 90°

Fine screen (30 mesh
or finer)

Attach screen to wooden frame
with removable brads or upholstery
tacks

(Intermediate, Junior High)

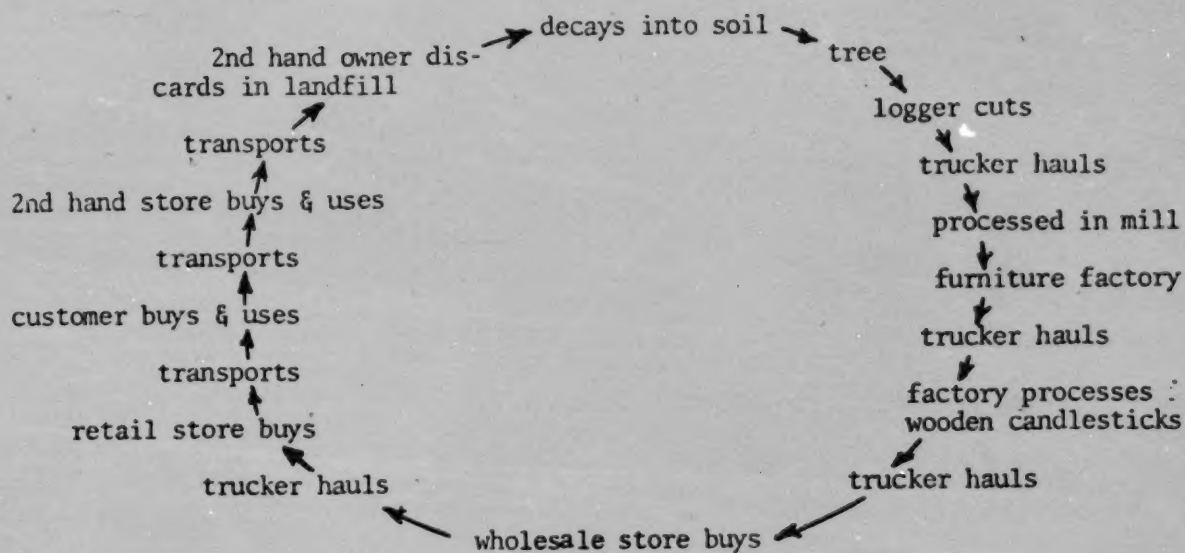
I. KEEP ON TRUCKIN'?

Ask each student to bring three items to class which are products of the forest ecosystem. These need not be wood products; they may be buckskin gloves from deer or wool clothes from sheep who lived or grazed in the forest.

Ask each student to choose one of the items and identify all of the steps necessary to produce the finished product from the raw material. They are then to identify all of the steps necessary to "recycle" the finished product back to the forest. On a large sheet of paper or on a chalk board, ask students to draw and label the points in the product's cycle-of-life.

For example:

CANDLESTICK



VARIATION:

The United States consumes 24 percent of its energy transporting products and people from one place to another. These products and people may be moved by any one of several carriers, each of which consumes a different amount of energy. Assign your students to use the information supplied in the tables to develop two resource cycles; one which expends the least amount of energy and one which uses the most. Through class discussion, compare these two cycles with reality.

1. Which cycle most nearly corresponds to what happens in real life? Is it the most energy-efficient cycle possible?

2. How much energy (in BTU's or calories) could be conserved by changing to more efficient modes of transportation? (Submit energy conservation suggestions to a local company which deals in the product "cycled.")
3. Is there anything you could do to make the cycle more energy efficient? Do it.

TABLE I

Energy Efficiency of Passenger Transport
(Source: E. Hirst, Oak Ridge National Laboratory)

Item	BTU ¹ Consumed/Passenger Mile	
	Urban	Between Cities
Bicycle	200	
Walking	300	
Buses	3700	1600
Railroads		1900
Automobiles	8100	3400
Airplanes		8400

¹1 BTU (British Thermal Unit) is equal to about 252 calories, which is equivalent to drinking about 1/2 of a malted milk.

(Junior High)

J. TREES AS HABITATS (ADOPT-A-TREE)

Ask students to observe their adopted tree for evidence of animal (insects, birds, small mammals) inhabitants. Ask them to draw as many animals as they can find which either live in or visit their adopted tree. Then, post these pictures on the bulletin board and have students attempt to find out (through personal observation and/or library research) the role that trees play in each of these animals' lives. Draw a large tree and illustrate the animals which contribute to changes in the tree. Discuss with students which changes may be beneficial or detrimental to the tree.

VARIATION I:

Take magnifying hand lenses outside with you for students to use to help them in drawing living things which are using their adopted tree. Ask students to make two columns on a piece of paper, one for drawing the animals they see and the other for recording the number of that species observed. A sample data sheet might look like this:

SPECIES	NUMBER
1. Ant	
2. Spider	

Compile this information for all the adopted trees and post the chart in the classroom. Have students recheck the trees over a period of several months and record the species and number changes. Other information might also be collected such as temperature, time of day, and general weather conditions (sunny, light rain, heavy snow).

Discuss:

1. Does the animal population remain constant on trees?
2. For what purposes were the various animals using the tree?
3. Is the tree being helped or harmed by the animals?
4. Does the weather influence the number and kind of animals present on the tree?
5. Do different species of trees have different kinds of animals on them?
6. Do some animals seem to prefer one tree species over another tree species?
7. Do some animals appear to be helping some tree species but hurting other tree species?
(Intermediate)

K. $SAP + ENERGY = SYRUP$

Materials:

Several pieces of copper or aluminum tubing, 3/8 inch to 1/2 inch in diameter, cut into 12-inch to 16-inch lengths.

Several 1-gallon tin cans.

Aluminum foil to cover the cans.

Wire or string to be used as bales for the cans.

Procedure:

During the early spring, when daytime temperatures begin to reach 40-50 degrees F. regularly and the nights still dip below freezing, ask your students to locate several large, hardwood trees. The tree trunks should be at least 10 inches in diameter. Maple is preferred, but many fruit trees also will yield small amounts of sap.

Give students these instructions:

Using a brace and a bit the same diameter as the tubing, drill a hole about 3-5 inches deep and 2-3 feet up from the base of the tree. The hole should be bored at a slight angle, sloping down and away from the tree, as shown in the illustration.

Use a wooden block or mallet to drive the tubing into the hole. You may need to clear the hole of wood chips from the drilling before inserting the tubing.

Hang the gallon cans from the tubing with wire or string and cover the cans with aluminum foil to keep out foreign matter, as shown in the illustration.

When several gallons of sap have been recovered, place the sap in a large kettle, bring it to a boil, and boil until sufficient water has evaporated to create a thick syrup.

Tell your students to record the amount of time and the quantity of sap required to produce the syrup. (Junior High)

L. PLANT FOOD

This activity examines the needs of plants for nutrients.

Materials:

Fertilizer (commercial chemical fertilizers work best because organic types rarely have the concentration required for this procedure)

Fast-growing seeds such as beans, marigolds, or radishes; enough to allow four seeds per group

Planting cartons (bottom halves of half-gallon milk cartons work well)

Potting soil (a mixture of vermiculite and peat moss)

Procedure:

Divide your class into groups of three or four students each.

Pre-soak seeds four to six hours.

Cut tops from milk cartons to make planting pots.

Give each group a specific amount of fertilizer to add to its portion of the soil. For example, Group 1 might receive no fertilizer; Group 2, one-half gram; Group 3, one gram, and so on. Each group should plant four seeds in its soil mixture, labeling the carton with the amount of fertilizer used. Each group should water its plants, using equal amounts of water, to keep the soil moist but not saturated.

As a class, observe the growth of the plants. Discuss:

1. Which seeds grew the best, those which received the most or the least fertilizer or those in-between?
2. Do you think it's possible to give a plant too much fertilizer?
3. Is the use of fertilizer an efficient use of our resources?

(Intermediate, Junior High)

M. SUCCESSION ON THE SCHOOL GROUNDS

Get permission to isolate, by means of temporary fencing, two areas near the school. The first should be a playground area (leave it alone) and the second a grassy or cultivated area near a building (stop mowing, watering, or fertilizing this area).

During a class term (semester, trimester, or quarter), students should take polaroid photographs of these two areas on a regular basis, probably once a week. The camera should be in the same position each time a photo is taken. This accurate pictorial record should be displayed in the classroom as the pictures are ready.

Students also should compare the areas by recording their observations in a journal, including this data:

1. Which plants and how many go to seed.
2. Plant growth rate: measure and graph in cm/week.
3. Changes in plant density: # of stems/m².
4. Changes in species composition: do some species become more abundant and others less abundant?
5. New species.
6. Evidence of animal life or visitation, including humans. (High School)

N. pH AND PLANTS

The pH of the soil has an important bearing on its chemical and microbial activity and significantly influences the growth of plants. The acidity or alkalinity of the soil can be modified both by natural processes such as fire and by cultural treatments such as human activity.

Soils generally lose their alkaline characteristics because of leaching of some minerals and the loss of some to plants. Plant litter also can alter soil pH significantly as it is reincorporated through decomposition into the soil.

As the hydrogen ion concentration increases in proportion to the hydroxide ion, the soil becomes increasingly acid; as the hydroxide ion increases in proportion to the hydrogen ion the soil becomes increasingly alkaline. This scale indicates the range of pH possible.

1	2	3	4	5	6	7	8	9	10	11	12	13
Very Acid		Moderately Acid				N e u t r a l			Moderately Alkaline		Very Alkaline	

Plants have narrow pH tolerance limits within which they thrive. To demonstrate this in the classroom, have students plant a variety of seeds in soils with different pH's.

To minimize the number of variables, the same soil may be used and its pH altered by the addition of lime (to make it more alkaline) or sulfur powder (to make it more acid).

Have students prepare a variety of seeds (preferably fast-growing ones such as beans, radishes, corn, and marigolds) by soaking them for 4-6 hours then planting several of each in soils of differing pH. Data such as the germination date, growth rate, and observations on general plant vigor and health should be recorded by the students for each test pot.

Discuss with the class which plants seem to prefer more or less acid soils.

(High School)

O. NATURE'S AIR CONDITIONERS

Direct each of your students to tie a plastic bag around a leaf on a tree. The bag should be secured tightly on the stem of the twig to which the leaf is attached and left for 24 hours.

Tell your students to observe the condensation of moisture on the interior of the plastic bag as a result of transpiration. Students should remove the bags carefully so that none of the water is spilled and measure the water by volume and by weight. Then they should answer these questions:

1. How much water did the leaf transpire in 24 hours?
2. Count the number of leaves on a small tree. How much water do you estimate was evaporated by the entire tree?
3. How might trees' transpiration affect the temperature and humidity in a forest? If possible, measure the temperature and humidity in a forest area and see if you are right.

(Junior High)

Social Science

A. TREE COOKIES

Obtain a large cross section of a tree which has recently been cut. Using large map pins, mark the annual rings and connect by string to a bulletin board indicating important events in a particular year of the tree's growth. How large was the tree when the school was built? When the class entered school? When the last president of the United States was elected? When they were born?

NOTE: The more sophisticated the class the greater the time span that may be dealt with in this lesson.

VARIATION (For Younger Students):

Using 2-inch to 3-inch diameter tree limbs (cross section), ask students to count the rings. (Use polished pieces with no more than 10 rings.)

Explain each ring equals one year of growth for the tree.

Ask:

How old is the tree (or limb)?

Do we have a tree as old as you?

How many rings would you have if you were a tree?

Is the cross section you have "more than" or "less than" the number of rings you are old?

(Primary, Intermediate)

B. THE SECOND LITTLE PIG

Ask your students to brainstorm a list of all the things made from wood used to build a house. Then use books, pictures, and interviews with architects, carpenters, contractors, and others involved with homebuilding to add to the list. This activity may be limited to one day or extended over several days.

Help your students to group the items on their list in categories such as these (you may wish to reword the headings to fit your class's needs):

EXTERIOR

shingles
siding
paint, etc.

INTERIOR

paint
varnish
paper
doors
moulding
cork flooring, etc.

NATURAL FIBER

plywood
shingles/shakes
2 x 4's, etc.

PROCESSED FIBER

paint
pressed woods
papers
wallpaper
rayon drapes

WHOLE WOOD

chip board
veneer
furniture
mop handles

OTHER THINGS WE GET FROM TREES

food
soap
cardboard
drugs
adhesives
shade
oxygen
scenery

(Intermediate)

C. WHY WOODEN PENCILS?

Distribute papers with these headings to your students: wood, plastic, steel, aluminum, copper, iron.

Divide your class into groups. Have a contest to see which group can come up with the longest list of products used in the school which are made from each of the materials named. You may wish to award tree seeds or seedlings as prizes to the winning group. (Contact a local forest industry nursery or your state's department of natural resources for seedlings.)

When the lists are complete and the winning group determined, ask each student to pick any three products, each made of a different material (for instance, a pencil, a metal locker, and a plastic table), and write a brief explanation of why that product was made from one material rather than another. In other words, why are most pencils made of wood rather than steel or plastic? What properties do these materials have which lend themselves to particular uses and not to others? Which are renewable? Reusable? Recyclable? (Intermediate)

D. RAINFALL AND THE FOREST

Obtain a map of your state which indicates the land area covered by forest. From the United States Weather Bureau or the state extension service, find out the average rainfall for various communities throughout the state.

Have your students make a transparent overlay of the state map, indicating the location of communities for which you have rainfall data. Students should mark the rainfall levels by recording the amount received at each location on your map. Indicate the areas with similar amounts of rain by using a color code. (Keep this simple by showing no more than four or five rainfall levels.)

When the overlay is complete, place it on the map. Then discuss some of these questions:

1. Do any of the rainfall levels correspond with the different types of forested areas?
2. Do forests occur only in areas with rainfall levels that are within a certain range? In other words, are there upper and lower rainfall limits for forest areas?
3. What other factors might prevent this type of forest or any forest from extending beyond its boundaries? (Soil types, urbanization, altitude, and temperature are some factors that should be mentioned.) Which of these are natural limits, imposed by the environment, and which unnatural, imposed by human activity?
4. How much rain do different types of trees seem to need?
5. How important are the forests in your state as watersheds?
6. Is rainfall needed by other elements in the forest besides trees? If so, name some and explain why rainfall is important to each. (Intermediate, Junior High)

PRECIPITATION TABLE

City	Elevation (Feet)	Average Maximum Temperature	Average Minimum Temperature	Average Precipitation (Inches)
Ajo	1,736	84.0	58.3	9.10
Alpine	8,000	61.9	24.8	20.73
Bisbee	5,350	74.0	48.7	18.44
Casa Grande	1,405	87.3	52.2	8.20
Clifton	3,465	81.0	52.5	12.54
Coolidge	1,419	86.8	50.9	8.74
Douglas	4,020	79.2	46.3	12.25
Flagstaff	6,993	60.4	30.6	20.23
Gila Bend	737	89.5	54.4	5.69
Globe	3,540	77.6	47.2	15.75
Grand Canyon	6,965	62.4	34.9	15.81
Holbrook	5,069	71.9	37.8	8.64
Kingman	3,345	76.4	46.4	10.63
McNary	7,320	62.3	30.8	24.70
Mesa	1,225	84.6	51.6	8.06
Miami	3,603	76.4	50.9	18.98
Nogales	3,800	79.5	45.0	15.60
Parker	425	88.2	52.6	4.83
Payson	4,910	70.9	34.8	21.48
Phoenix	1,117	84.7	55.8	7.46
Prescott	5,410	69.7	35.8	19.32
Safford	2,900	80.3	46.1	8.95
Springerville	6,964	65.8	31.5	12.11
Tempe	1,150	84.8	52.2	7.66
Tucson	2,410	82.3	52.4	11.25
Wickenburg	2,070	82.7	46.8	10.99
Willcox	4,200	76.6	40.8	11.76
Williams	6,750	64.2	32.8	21.88
Winslow	4,880	70.5	39.8	7.34
Yuma	138	87.1	58.2	3.38

Source: U.S. Weather Bureau Records

E. START A CITY

Divide your class into four or five groups and equip each with a base (it could be masonite, plywood, or cardboard), glue, and scissors. Announce the assignment: each group is to build a pioneer village for a specific area of the United States, such as the Northeast, desert Southwest, prairie, or Pacific Northwest. Each group should research the area it is assigned to determine the construction materials which would have been available to pioneers in that part of the country. Students then should collect similar materials from the school grounds, their homes, or community sources and build their village from these materials. The village should include homes, smokehouses, outhouses, barns, and perhaps a church or a store.

When all the villages are completed, put them on display and lead a class discussion to compare the materials used.

1. How did available building materials influence the type of homes constructed?
2. How is it possible that modern homes in the prairie states are built of wood?
3. What materials are used to build modern homes? Why?
4. Why aren't modern homes built of sod or entirely of stone?
5. How well do the different materials used insulate and protect against the elements? Are some materials more suitable for construction in certain climates than in others?
(Junior High)

F. VACATION HOMES

Prepare this scenario for distribution to students:

"There are 50 summer cabins on Tonto National Forest land along Tonto Creek. These cabin sites were leased to private citizens 30 years ago when forest recreation was very light in this area.

Since then, the nearest city has grown tenfold and recreation demand in the Tonto Creek area is almost 20 times what it was 30 years ago.

Some people feel that those 50 cabins should no longer be permitted to dominate that area of Tonto Creek and that the land belongs to all of the people.

Should 50 families have Tonto Creek to themselves or should their leases be terminated and the cabins removed? Should the cabin owners be allowed to remove the cabins? Should they be reimbursed for their value?"

Divide the class into these three groups:

1. Three or four members representing the Forest Service Advisory Board. They will conduct a hearing and arrive at a decision.

2. Half of the remainder of the class will role-play the cabin owners.
3. The other half of the class will represent the general public.

Allow the groups time to prepare testimony stating their reasons for either renewing the leases or abolishing them. During this period the U. S. Forest Service Advisory Board plans the hearing procedures; i.e. who testifies, for how long, in what order, etc.

Have groups study the sample Tonto lease that follows on the next page.

When all groups feel they are ready, the hearing is convened. After the testimony has been presented and opportunity for rebuttal provided, the Advisory Board meets separately to reach a decision. They return and report their decision to the entire class and explain the reasons for their decision.
(Junior High, High School)

G. FOR BETTER OR FOR WORSE?

Present this situation to your students:

Some time ago, Inter State Paper Company officials, in order to comply with new air and water pollution regulations, hired pollution-control technicians to study the company's manufacturing operation. The technicians now have presented a pollution-reduction plan to Inter State's board of directors. The new process would reduce odorous gas emissions (air pollution) by 95 percent and the B.O.D. (a measure of water pollution) added to the river by 94 percent. The control measures would cost an estimated \$11 million to \$12 million but, with some state assistance, the company will be able to install the new process within a few years.

The new process would have the additional benefit of enabling the company to recover and reuse or sell most of the waste products now dumped into the river and air.

There is one problem. The new process would require substantial amounts of electricity. The power can be obtained from a coal-fired plant that would have to be constructed. This plant also would require pollution-control devices but it would have the advantage of generating enough new electricity to meet the increasing energy needs of the community as well as those of the paper plant. Coal for the plant most likely would come from strip mining but this issue will be decided by pending federal legislation.

Inter State has proposed an alternative to the coal-fired plant. The company believes it can supply the additional electricity needed by installing a wood and wood-waste fired boiler in its plant. Drawbacks are that this boiler would cost three times as much as one using only coal or gas and it would not produce any excess power for the community. Inter State would have to raise prices for its products to get the necessary funds and the community's energy needs would not be met.

After students have familiarized themselves with the situation, discuss these questions:

1. What are the advantages and disadvantages of Inter State producing its own energy?
2. What are the advantages and disadvantages of a new coal-fired power plant?

SAMPLE USE PERMIT

United States Department of Agriculture Forest Service TERM SPECIAL USE PERMIT <i>Act of March 4, 1915, as amended July 28, 1956, or Act of March 30, 1948</i>		NAME OF PERMITTEE	KIND OF USE
		DATE OF PERMIT	FILE CODE
REGION	STATE	FOREST	RANGER DISTRICT
3	2-Arizona	12-Tonto	04-Payson

Permission is hereby granted to JOHN DOE

of _____
 hereinafter called the permittee, to use subject to the conditions set out below, the following described lands or
 improvements for the period of 20 years from the date hereof:

Lot 3 of the Thompson Draw Summer Home Area, located in approximately Sections
 29, 30, and 32, T. 11 N., R. 12 E., G&SRB&M, as shown on file in the office of the Forest
 Supervisor, Tonto National Forest, Phoenix, Arizona.

This permit covers one-third acres and/or XXXXXXXXXXXXXXXXXXXX miles and is issued for the purpose
 of:

Maintaining a summer home.

This supersedes permit issued to JOHN DOE on
5-5-54, for residence.

The exercise of any of the privileges granted in this permit constitutes acceptance of all the conditions of this
 permit.

1. In consideration for this use, the permittee shall pay to the Forest Service, U. S. Department of Agriculture,
 the sum of Forty-Five and no/100 Dollars (\$ 45.00) for the period from
January 1, 19 66, to December 31, 19 66, and
 thereafter annually on See Clause 20 for fees to be charged,
 Dollars (\$ _____):

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
 XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

2. Construction or occupancy and use under this permit shall begin within Constructed months, and
 construction, if any, shall be completed within Completed months, from the date of the permit. This use shall be
 actually exercised at least 365 days each year, unless otherwise authorized in writing.

3. Development plans; lay-out plans; construction, reconstruction, or alteration of improvements; or revision of
 lay-out or construction plans for this area must be approved in advance and in writing by the forest supervisor. Trees
 or shrubbery on the permitted area may be removed or destroyed only after the forest officer in charge has approved,
 and has marked or otherwise designated that which may be removed or destroyed. Timber cut or destroyed will be
 paid for by the permittee as follows: Merchantable timber at appraised value; young-growth timber below merchantable
 size at current damage appraisal value; provided that the Forest Service reserves the right to dispose of the
 merchantable timber to others than the permittee at no stumpage cost to the permittee. Trees, shrubs, and other plants
 may be planted in such manner and in such places about the premises as may be approved by the forest officer in
 charge.

4. The permittee shall maintain the improvements and premises to standards of repair, orderliness, neatness, sanitation, and safety acceptable to the forest officer in charge.

5. This permit is subject to all valid claims.

6. The permittee, in exercising the privileges granted by this permit, shall comply with the regulations of the Department of Agriculture and all Federal, State, county, and municipal laws, ordinances, or regulations which are applicable to the area or operations covered by this permit.

7. The permittee shall take all reasonable precaution to prevent and suppress forest fires. No material shall be disposed of by burning in open fires during the closed season established by law or regulation without a written permit from the forest officer in charge or his authorized agent.

8. The permittee shall exercise diligence in protecting from damage the land and property of the United States covered by and used in connection with this permit, and shall pay the United States for any damage resulting from negligence or from the violation of the terms of this permit or of any law or regulation applicable to the national forests by the permittee, or by any agents or employees of the permittee acting within the scope of their agency or employment.

9. The permittee shall fully repair all damage, other than ordinary wear and tear, to national forest roads and trails caused by the permittee in the exercise of the privilege granted by this permit.

10. No Member of or Delegate to Congress or Resident Commissioner shall be admitted to any share or part of this agreement or to any benefit that may arise herefrom unless it is made with a corporation for its general benefit.

11. Except as provided in Clause 16 below, upon abandonment, termination, revocation, or cancellation of this permit, the permittee shall remove within a reasonable time all structures and improvements except those owned by the United States, and shall restore the site, unless otherwise agreed upon in writing or in this permit. If the permittee fails to remove all such structures or improvements within a reasonable period, they shall become the property of the United States, but that will not relieve the permittee of liability for the cost of their removal and the restoration of the site.

12. This permit is not transferable. If the permittee through voluntary sale or transfer, or through enforcement of contract, foreclosure, tax sale, or other valid legal proceeding shall cease to be the owner of the physical improvements other than those owned by the United States situated on the land described in this permit and is unable to furnish adequate proof of ability to redeem or otherwise reestablish title to said improvements, this permit shall be subject to cancellation. But if the person to whom title to said improvements shall have been transferred in either manner above provided is qualified as a permittee, and is willing that his future occupancy of the premises shall be subject to such new conditions and stipulations as existing or prospective circumstances may warrant, his continued occupancy of the premises will be authorized by a permit to him, which may be for the unexpired term of this permit or for such new period as the circumstances justify.

13. In case of change of address, permittee shall immediately notify the forest supervisor.

14. The temporary use and occupancy of the premises and improvements herein described may not be sublet by the permittee to third parties without the prior written approval of the forest supervisor and the permittee shall continue to be responsible for compliance with all conditions of this permit by persons to whom such premises may be sublet.

15. This permit may be terminated upon breach of any of the conditions herein.

16. If during the term of this permit or any extension thereof, the Secretary of Agriculture or any official of the Forest Service acting by or under his authority shall determine that the public interest requires termination of this permit, this permit shall terminate upon thirty days' written notice to the permittee of such determination, and the United States shall have the right thereupon to purchase the permittee's improvements, to remove them, or to require the permittee to remove them, at the option of the United States, and the United States shall be obligated to pay an equitable consideration for the improvements or for removal of the improvements and damages to the improvements resulting from their removal. The amount of the consideration shall be fixed by mutual agreement between the United States and the permittee and shall be accepted by the permittee in full satisfaction of all claims against the United States under this clause: *Provided*, That if mutual agreement is not reached, the Forest Service shall determine the amount and if the permittee is dissatisfied with the amount thus determined to be due him he may appeal the determination in accordance with Regulation A-10 (36 CFR 211.2) and the amount as determined on appeal shall be final and conclusive on the parties hereto; *Provided further*, That upon the payment to the permittee of 75% of the amount fixed by the Forest Service, the right of the United States to remove or require the removal of the improvements shall not be stayed pending final decision on appeal.

18. In the event of any conflict between any of the preceding printed clauses or any provision thereof and any of the following clauses or any provisions thereof, the preceding printed clauses will control.

19. This permit is accepted subject to the conditions set forth above and to conditions 20 to 31 attached hereto and made a part of this permit.

DATE	SIGNATURE OF ISSUING OFFICER	TITLE
DATE	SIGNATURE OF PERMITTEE	
SEE LAST PAGE FOR SIGNATURES		

Thompson Draw

20. Annual fees for years 1967 through 1969 will be as follows:

1967 — \$50.00
1968 — 55.00
1969 — 60.00

Effective January 1, 1970 and thereafter, as of, and effective on, the beginning of each 5-year period, the charges for this use shall be readjusted in order to place the charges on a basis commensurate with the value of use authorized by this permit.

21. Only one residence and one garage will be permitted on this lot. Nonessential auxiliary buildings such as tool houses, storage sheds, or boat houses are prohibited. Garages shall not be converted to living quarters.
22. No mobile home or house trailer will be permitted upon the premises without the written consent of the Forest Supervisor.
23. The permittee shall install at specified locations the types, capacities, and numbers of fire extinguishers and other fire-fighting apparatus as designated by the Forest Supervisor or his designated representative.
24. No fireworks shall be stored or used on the land covered by this permit or in the structures thereon.
25. The permittee shall:
 - (a) Keep the roofs, rain gutters, chimneys and stove pipes free of all flammable materials, and shall remove tree branches which overhang chimneys and stove pipes.
 - (b) Install a spark arrester satisfactory to the district ranger, on chimneys and stove pipes.
 - (c) Be responsible for the suppression of all fires originating upon the permitted lot.
26. All electric equipment and facilities installed and operated shall conform to the National Electric Safety Code and applicable equipment must have been approved by the Underwriters' Laboratory.
27. No fences shall be erected upon the premises unless approved in writing by the Forest Supervisor.
28. No animals or fowl, other than dogs and cats, shall be brought or kept upon the premises, unless approved in writing by the Forest Supervisor.
29. The permittee assumes the risk of damage or injury from avalanches, rising waters, high winds, and falling limbs of trees and other hazards of this nature, and has the responsibility of inspecting his lot and immediate adjoining area for dangerous trees, hanging limbs, and other evidences of hazardous conditions and securing permission from the local forest officer to remove such hazards.

30. Neither the execution and delivery of this permit nor anything herein contained shall be construed as a representation, warranty or covenant by the United States as to the conditions of the premises, the suitability for use or enjoyment or the future maintenance, development, improvement or protection of the premises. It is understood that the United States is in no way liable, by virtue of the execution and delivery of the permit or the terms thereof, for any damage to or loss of the property of the permittee or others or for injury to the person of permittee or others.
31. None of the conditions of the permit as set forth herein can be varied or modified except with the written consent of the Forest Supervisor.

U. S. FOREST SERVICE
Tonto National Forest

Date _____

By _____
Forest Supervisor

The foregoing permit has been read by the undersigned permittee(s), and I (We) agree to accept and abide by its terms and conditions.

Date _____

Permittee

Date _____

Permittee

Special Information

Regulation A-9 of the Secretary of Agriculture authorizes the formation of associations of National Forest permittees. A majority of the summer-home permittees in the area of this permit have requested and obtained approval to organize an association, called the Thompson Draw Summer Home Association. You are eligible to membership. Even though you do not join, you may be required to pay an equitable share of the cost of installation and operation of services or utilities which the association voted and which the Regional Forester approved.

3. If the company installs its own boiler and then raises its paper prices, what effect might there be on sales? Would you be willing to pay more for your paper? Would you be willing to use less?
4. What implications does the choice of a power source have on the future of the company and of the community?
5. What are the trade-offs involved in this situation?
6. What options are available to the community?
7. If you lived in this community, which option would you choose? Why?

(High School)

H. A LOOK AT LIFE-STYLES

Ask your students to list the renewable and nonrenewable resources they have used or consumed in the past 24 hours and identify each as (1) essential for survival, (2) necessary for maintenance of their present life-style, or (3) a luxury.

Students then should propose alternatives for each item listed in categories two and three which they believe are inefficient or wasteful. Compile a master list of the resources used and the proposed alternatives and discuss these questions:

1. Are any items listed in the "essential" category really not essential? What is your criteria for evaluating an item's necessity?
2. Are any items listed in the second category really luxuries? On what basis do you judge an item a luxury?
3. What would be the environmental and economic impact of your alternatives? Would they increase the use of renewable resources? (For instance, switching from aluminum foil to cellophane food wrap would accomplish this.) Or, would they increase the use of nonrenewable resources? (Switching from paper cups to plastic cups would have this effect.) Would they increase the use of energy?
4. Look at the list of luxury items. Which of these could you give up without a major change in your life-style?
5. Make a list, beginning with the easiest to give up and ending with the most difficult. Could you give up the top three items on this list for a day? A week? A month? Do it.

I. COMMUNITY LAND USE

Divide the class into four groups. Each group will study your community's land use in one of four time periods: the present; 25 years ago; 50 years ago; and 100 years ago.

Group members will collect data from community records, including old maps and photographs, and make a map illustrating the land-use pattern during the period they are investigating. All four maps should be made to the same scale.

After the maps are completed, students will compare the land-use patterns and discuss the changes.

Has the community's size changed? If so, how?

Has the land-use pattern changed? What uses have increased? What uses are decreasing? Have any of the original uses disappeared?

Ask students, either individually or in small groups, to interview residents who have lived in the community for from 25 to 50 years to find out their perceptions of changes. If possible, the interviews should be recorded on tape.

From the interviews, students can determine:

1. What was the general ratio of people who believed the land-use changes were harmful as compared to those who believed they were helpful?
2. What reasons did the residents give for their opinions on the changes?
3. Do any residents who believed a change would be helpful at the time it took place now think it was detrimental to the community? Do any of them believe a change they originally thought was harmful has turned out to be beneficial?

(NOTE: Students should consider facts which might affect the validity of the data obtained from responses to their questions. Most people don't like to admit they were mistaken.)

The class then should discuss what land-use changes appear to be coming in the future. Do the students think these will be helpful or harmful? Ask them to state reasons and criteria to support their opinions. Can the students suggest mechanisms available to insure that most changes will be beneficial?

J. ... AND A SIDE ORDER OF PAPER

The take-out, fast-food industry has a big appetite for paper. It uses hamburger wrappers; boxes for the wrapped hamburgers; cardboard trays for the bag and the box and the wrappers; napkins; straws wrapped in paper; salt, pepper, sugar, and powdered cream in paper packets; coffee cups; soft drink cups. And all the packaging is discarded within 15 minutes after its contents are consumed, a practice that contributes to the country's solid waste problem. Energy studies show that the equivalent of 12.7 million tons of coal and a sustained yield of 315 square miles of forest was used to provide packaging materials for hamburgers sold by just one fast-food chain in 1971 (*Chicago Sun Times*, Monday, October 30, 1972, "Fast Foods Squandering U. S. Resources" by Bruce Ingersoll).

This study project examines the trade-offs, economic and environmental, involved in the consumption of resources through packaging.

Divide the class into small groups. Each group will survey a local fast-food restaurant to find out how much paper it uses in a given period of time, such as a week or a month. Before beginning the survey, students should make up a questionnaire to be used when they interview the restaurant manager.

Suggested questions are:

1. What items made of paper does your establishment use?
2. How many of each item do you use per (insert time period)?
3. What companies supply these paper items?
4. Why do you use paper packaging? (Answers might relate to cost, convenience, health codes, etc.)
5. Do you think you are overpackaging your products? (Remember, you want to keep the restaurant manager friendly, so be careful how students phrase this question.)
6. What percentage of the total cost of your product does the packaging represent?
7. How much do your employees make per hour?
8. Where and how do you dispose of your restaurant's solid waste (e.g., landfill, incinerate, recycle, etc.)?

When students have completed their interviews and tabulated their data, explore some of the following questions:

1. What were the principal reasons given for the use of paper packaging?
2. Are any of the paper items used by the fast-food outlets produced locally? If so, how many jobs are dependent upon sales of these products? (Don't forget printing, transportation, manufacturing of machines to print, making paper, etc.)

VOCABULARY

algae ('al-jei) — Single cell plants; chiefly aquatic nonvascular.

alpine ('al-pin) — Refers to organisms that grow on elevations above the timberline.

annual — A plant which lives one year.

carbohydrate (,kar-bo-hi-drat) — A substance (sugars and starches) composed of carbon, hydrogen, and oxygen. It is made in the green leaves of plants from carbon dioxide, water, and energy from sunlight.

carbon dioxide — A harmless, colorless gas which is necessary for plant growth; shown as CO_2 .

carnivore (kar-na-vo(a)r) — A meat-eating animal.

carrying capacity — (animal) The number of animals a given amount of space (acre, section, etc.) can support. Capacity will vary from week to week and season to season.

chaparral — Brushy areas made up of manzanita, ceanothus, cliffrose, scrub oak, skunk brush, and others.

chlorophyll (klor-a-fil, 'klor-a-fal) — A green, nitrogenous substance found in plants and which is necessary for photosynthesis; it serves as a catalyst in the chemical reaction that makes carbohydrates from carbon dioxide and water.

chloroplasts (klor-,plast, 'klor-) — Small oval bodies found in the cells of leaves; they contain the chlorophyll.

climax plants — The final type(s) of plants that persist in an area that has undergone a succession of plant changes. Ponderosa pine and saguaro-palo verde are climax plant types.

consumer — A living organism that gets its food by devouring all or part of another living thing. It is usually an animal.

decomposers (de-kam-po-zar) — Organisms that cause decay of plant and animal remains (examples: fungus, bacteria, microscopic animals).

ecosystem — Any natural unit that includes living and nonliving parts interacting to produce a stable system in which the exchange of materials between living and nonliving parts follow circular paths. The largest conceivable ecosystem is the entire earth. However, the general concept of an ecosystem is much smaller.

fats — An energy-rich food substance produced by both plants and animals when they have more food than they use for normal processes.

food chain — A figure of speech which illustrates how living things produce food that is consumed by other living things. All living things are part of a food "chain." Some food chains are quite simple, but most of them are very complex.

fungus (fan-gas) – A simple plant that does not have chlorophyll, and has to live on plant or animal tissue. If it grows on a living organism it is a parasite; if on dead matter it is a saprophyte. Plural: fungi.

habitat – The place or site where a plant or animal naturally or normally lives and grows; a complex of soil, water, and plants.

herbivore ('(h)er-ba-,vo(a)r, -,vo(a)r) – A plant-eating animal.

humus – Decaying vegetation (some animal matter) that is being returned to the soil. The terms humus, litter, mulch, and organic matter are closely related. Soil with much humus is usually black and called "rich."

lichen ('likan) – A group of plants composed of algae and fungus growing together.

litter – Not the same thing as the refuse scattered along the roads by inconsiderate people. This litter consists of the leaves, stems, and other plant materials that have fallen to the ground. It will be returned to the soil if left on the ground.

mulch ('malch) – Often is the same thing as humus or litter, although mulch may be chopped up, loose material used to protect the soil from evaporation.

nutrients – (plant) Raw materials taken in by plants for use in carrying on their many functions. There are at least 15 elements essential for proper plant growth. These are carbon, hydrogen, oxygen, phosphorus, potassium, nitrogen, sulfur, calcium, iron, magnesium, boron, copper, zinc, manganese, and molybdenum.

organic matter – Parts of plants (and animals). Usually refers to the vegetative matter found in the soil (like humus).

parasite ('par-a,sit) – An organism that gets its nourishment from another living organism. The mistletoe, which lives on many species of trees, is an example. It has green leaves to make carbohydrates, but its roots take sap from the tree, rather than water and nutrients from the ground. Many species of fungi also are parasites; they have no flowers or leaves and cannot manufacture carbohydrates.

perennial (pa-'ren-e-al) – A plant that lives longer than one year. Some get to be thousands of years old, such as the redwood trees.

photosynthesis (,fot-o-'sin(t)-tha-sas) – The process by which plants manufacture carbohydrates with the help of sunlight and chlorophyll.

plant community – A group of plants growing together naturally. Differences in plant communities are caused by differences in moisture, temperature, soil, and slope, and make Arizona vegetation an interesting contrast.

producer – A green plant that *makes* food from raw materials.

protein ('pro-,ten, 'prot-e-an) – A complex food substance synthesized by plants from such raw materials as carbon, hydrogen, oxygen, and nitrogen. It is the "building material" of plants and animals.

relative humidity — Refers to the amount of moisture or water vapor in the air. Varies with temperature and pressure.

renewable resource — A resource (such as timber and wildlife) that can renew itself after it has been properly harvested.

respiration — The breaking down of carbohydrates to provide energy for plant and animal activity and growth.

shrub — A woody plant with many branches and without a well-defined central trunk; commonly less than eight feet high. Also called "bush" or "brush."

stomata (sto-mat-a) — (plural of stoma) A minute pore in the leaf through which water and gases are exchanged.

transpiration (tran(t)s-pa'ra-shan) — Movement of water through the stomata of the leaves.

tree — A woody plant with a central trunk and commonly more than eight feet high when mature.

NOTE — See Wildlife Vocabulary section for additional terms common to plants and animals.

BIBLIOGRAPHY

The following list of resource materials and sources is just a beginning but it should help you get started with your study of plants. No effort has been made to recommend any one particular resource over any other; whether listed or otherwise.

NOTE: Please check the wildlife, soil, and other sections for ideas and sources of materials.

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ROCKS & MINERALS



ROCKS AND MINERALS

Introduction:

Everything we use in our day-to-day living depends, to some extent, on minerals. Everything comes from the crust of the earth; and three industries, mining, agriculture, and fishing, remove from the earth these raw materials and make them available for man's use.

The earth is a ball of rock—7,927 miles in diameter. It weighs about 6.6 sextillion tons. (A sextillion is a million to the 6th power—1,000,000,000,000,000,000,000.) Continents are islands of granitic rock floating on the denser, darker, basaltic rocks which underlie the ocean basins. Rocks and minerals are sources of metal, fuel, and building materials. The way we use minerals is a clue to our progress. Some civilizations died because they never learned to extract metallic ore from rocks or to make the soil produce. One reason for America's progress is the abundance of mineral wealth in North America. This continent is the world's largest producer of aluminum, copper, lead, sulfur, gypsum, and natural gas.

One of the most important products of rocks and minerals is soil. The parent material of soil is rock, to which is added decaying animal and vegetable matter, oxygen, water, and living organisms. The average depth of the earth's soil is about one foot, yet this foot of soil produces nearly all of our food, timber, and fiber.

We live in a metals-based culture. Man emerged from the Stone Age when he first began making tools of metal instead of stone some 10,000 years ago. More than 85 percent of the world's presently known reserves of copper minerals are located in only six major areas of the globe. The greatest concentration of copper in the United States is in the North American Cordillera, notably in the Basin and Range Province of the Southwest which includes most of southern Arizona.

Arizona is a mining state. Our history is strongly associated with minerals. Spanish explorers first came through what is now Arizona more than 400 years ago in search of precious metals. With the possible exception of very early trapping expeditions by Pauline Weaver and other frontiersmen, beginning around 1820, interest in creating an Arizona Territory in 1863 was largely because of the gold and silver mining activities. The Gadsden Purchase was made in 1853 because the "Fortyniners," following the Gold Rush of 1849, needed easy transportation routes and these were in southern Arizona and New Mexico. The first Americans to mine copper in Arizona did so the following year, 1854, near what is now Ajo.

Arizona is and has been the leading copper-producing state for 50 years. At present, the mining industry in the State produces more than half the copper in the United States. Even this great quantity of copper must be supplemented by imports from other countries in order to supply America's needs. If our mines could supply today's demand for copper, or any other mineral, we must still understand that these minerals are *nonrenewable* resources, and that even these huge deposits are not inexhaustible. We can deplete our mineral resources.

There is no second crop of minerals. More minerals have been mined in the last 35 years than in all preceding history.

BASIC CONCEPT NO. 1 – Rocks and minerals are classified according to their origin.

Suggested Activity – Science

Find a rock.

Identify its mineral! Use a microscope or hand lens. See the mineral guide in the activity section.

Understandings:

A. A mineral has a precise definition.

Scientifically, a mineral is defined as any naturally occurring inorganic substance having a definite chemical formula. A mineral has more or less constant physical properties, and if formed under favorable conditions, a characteristic crystalline form. Moreover, a mineral must be a homogenous substance, even when minutely examined with the aid of a microscope.

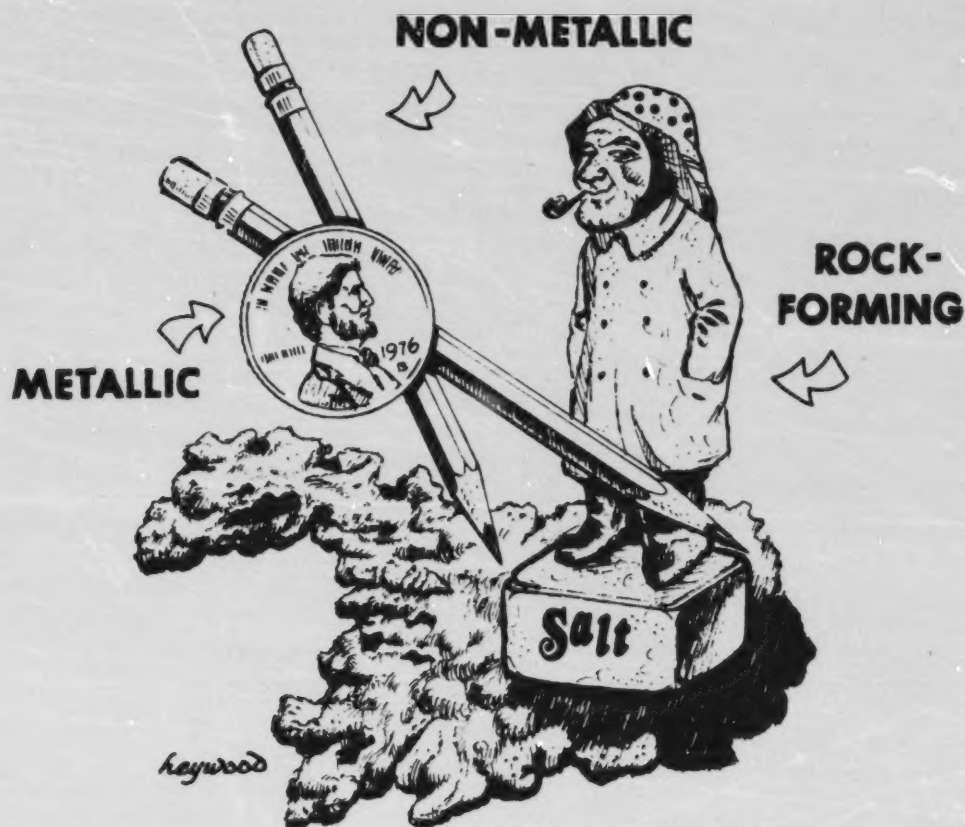
The world contains more than 1,100 kinds of minerals. These can be grouped in three general classes.

1. *Metallic minerals.* These include things most of us would think of if we were asked to name some minerals. Familiar examples are copper, silver, mercury, iron, nickel, and cobalt. Most of them are found in combination with other things—as ores. We get lead from galena, or lead sulfide. Tin comes from the ore cassiterite; zinc from sphalerite and zincblende, or blackjack. Chromium that makes the family car flashy comes from chromite. Many minerals yield aluminum. Uranium occurs in about 50 minerals, nearly all rare. Twenty-four carat gold is a metallic mineral. A 14 carat gold ring contains 14/24ths, or 58 percent, gold.

An average sample of earth contains 9% aluminum, 5.5% iron, .01% zinc, .008% copper, .004% tin, .002% lead, .0005% uranium, and .0000006% gold or platinum. It would be hopelessly expensive to recover such metals from an average ton of earth. That's why metallic minerals are taken from concentrated deposits in mines.

Many valuable minerals are found in veins running through rock. Veins can be formed when: (a) mineral-laden ground water seeps into cracks, evaporates, and leaves mineral grains that build up into a vein; (b) hot water from deep within the earth fills cracks, then cools and deposits much of the material in solution as minerals in a vein—sometimes including metals such as gold and silver; (c) molten, gaseous material squeezes into cracks near the earth's surface, then slowly hardens into a vein.

2. *Nonmetallic minerals.* These are of great importance to certain industries. You'll find them in insulation and filters. They are used extensively in the ceramic and chemical industries. They include sulfur, graphite (the "lead" in pencils), gypsum, halite (rock salt), borax, talc, asbestos, and quartz.



3. *Rock-forming minerals.* These are the building materials of the earth. They make mountains and valleys. They furnish the ingredients of soil and the salt of the sea. They are largely silicates—that is, they contain silicon and oxygen. (Silicon is a nonmetallic element, always found in combination with something else. It is second only to oxygen as the chief elementary constituent of the earth's crust.)

Other rock-forming minerals are the large family of micas, with names like muscovite and phlogopite. There are the feldspars, including albite and orthoclase. Others are amphiboles, pyroxenes, zeolites, garnets, and many others you may never find or hear about unless you become a true mineralogist.

A rock may be made almost entirely of one mineral or of more than one mineral. Rocks containing different combinations of the same minerals are different. Even two things made of the same single mineral can be quite different. Carbon may turn up as a lump of coal or a diamond.

DID YOU KNOW HOW MINERALS GOT THEIR NAMES?

Names of most minerals end in "ite"—apatite, calcite, dolomite, fluorite. But many do not: amphibole, copper (the most common pure metal in rocks), feldspar, galena, gypsum, hornblende, mica, quartz.

Many minerals take their names from a Greek word referring to some outstanding property of the mineral. For example, hematite, an oxide of iron, was named about 325 B.C. from the Greek haima, or blood, because of the color of its powder.

Some minerals are named for the locality in which they were first discovered. Coloradoite was first found in Colorado. Benitoite turned up in San Benito County, California. And so also with labradorite and brazilite.

Other minerals got their names from famous people. Willemite was named in honor of Willem I, King of the Netherlands. The great German poet-philosopher, Goethe, could turn up in your collection as goethite. And there's smithsonite, named for James Smithson, founder of the Smithsonian Institution.

Some minerals come from outer space. They're in meteorites, which are rock fragments. Every day, hundreds of millions of them enter the earth's atmosphere. Most of them, however, are burned up by the heat from air friction and never reach the ground. Meteors large enough to reach the earth are called meteorites. Most minerals found in meteorites are the same as those we have on earth. However, there are some rare minerals known only in meteorites. Two of them are cohenite and schreibersite.

B. A rock is formed of one or more minerals.

A rock is defined as the solid material which comprises an essential part of the earth's crust. Rocks range greatly in composition, and geologists have established several classifications of them. Some rocks are large masses of a single mineral, like marble; other rocks are composed of a mixture of minerals, like granite or conglomerates. There are three main classifications of rocks, based on origin:

1. *Igneous rocks* are those formed at very high temperatures or from molten materials. They come from magmas—molten mixtures of minerals, often containing gases. They come from deep below the surface of the earth. If they cool off while below the surface, they form intrusive rocks, which may later be revealed by erosion. When magmas reach the surface red hot, they form extrusive rocks, such as volcanic rocks. Thus, granite is an igneous, intrusive rock; lava is an igneous, extrusive rock. (Notice how the type of rock tells its past history—if you know what to look for.)
2. *Sedimentary rocks* are formed by the action of wind, water, or organisms. They cover about three-quarters of the earth's surface. Most are laid down, as sediments, on the bottoms of rivers, lakes, and seas. Many have been moved by water, wind, waves, currents, ice, or gravity. The most common sedimentary rocks are sandstones, limestones, conglomerates, and shales. Oil is found in sedimentary formations, as are fossils.

3. *Metamorphic rocks* are those that have been changed from what they were at first into something else—by heat, pressure, or chemical action. All kinds of rock can be changed. The result is a new crystalline structure, the formation of new minerals, or a change in the rock's texture. Slate was once shale. Marble came from limestone. Gneiss (pronounced "nice") is perhaps reworked granite.

BASIC CONCEPT NO. 2 — Minerals are vital to Man's Activities.

Suggested Activity — Mathematics

There are approximately 500 pounds of copper in an average, modern home. A mining company can recover 12 pounds of copper from a ton of ore. How many tons of ore must be mined for each home? For each ton of ore the miners must remove two tons of waste, called "overburden." How many tons of material must be dug in order to build a house? Can you figure out how big the hole would be? How many tons of ore would be mined to supply your town or city? How many tons of total material? How big would the hole be if all the copper for your community was taken from it?

Understandings:

A. Man uses minerals in a variety of ways.

1. Elements such as copper, gold, silver, and iron which we use to make jewelry and tools, machinery, weapons, and thousands of other wants and needs.
2. Minerals such as granite, marble, sand, and gravel are used to build highways, homes, skyscrapers, and libraries.
3. Natural gases, coal, and oil, which, when burned, supply energy for travel, industry, and electric lights. Certain minerals such as uranium also supply this kind of energy—as well as atom bomb material.
4. Another important use of minerals is in agriculture. The farmer uses lime, sulfur, potassium, phosphates, and other minerals to enrich the soil, and the rancher puts out blocks of mineral salts for his livestock.



B. Man has always been dependent on minerals.

1. Metals, stone, and clay were mined and used even in prehistoric times. Coal was mined by Indians in the Four Corners area of Arizona hundreds of years ago.
2. The use of solid fuels taken from the earth (the fossil fuels) first became significant with the start of the Industrial Revolution.
3. Modern agriculture is dependent on a multitude of minerals, from the metals in modern farm implements and machinery to the many soil additives to increase production.



BASIC CONCEPT NO. 3 – The wealth of a state or nation is largely determined by its rocks and minerals.

Suggested Activity – Social Science

Obtain a geologic map for your county; compare the value each county derives from rock and mineral resources. Enlarge this study to a nationwide survey.

Understandings:

A. Earth's resources influence man's lifestyle.

Geologic history has divided Arizona into two unlike parts. We call the northern part the Plateau province and the southern part the Basin and Range province. It is interesting to see just how these large geologic differences influence life in Arizona:

	Plateau	Basin and Range
Population	8.0 percent	92.0 percent
Value of Mineral Production	3.0 percent	97.0 percent
Agricultural Acreage	2.7 percent	97.3 percent

Population follows industry and industry goes where there is water, soil, mineral resources, grazing land, and acceptable climate, among other considerations. All of these things are present in much greater quantity in the basin and range half of Arizona.

B. Geologic history determines the natural resources of an area.

Geologic history is not the same everywhere and we have given as examples:

1. Copper in Arizona as compared to other states in the United States (Table II).
2. Mineral resources (especially copper) in southern Arizona as compared to northern Arizona. Just as geologic history is different within Arizona, so it is for the many nations of the world. Many countries lack the important earth resources that we enjoy in the United States.

C. Mineral resources are not evenly distributed on the earth.

The following explanation is given by an American geologist (Gilluly, 1962), "Mineral resources are never evenly distributed in the earth's crust. They are sporadic, concentrated in relatively small areas and, most important of all, they are exhaustible. These facts of great social and political implication are often overlooked by economists, historians, and politicians . . . mineral deposits of all kinds are essentially freaks of nature. The average rock is no economic source of metals or of fuels. It is the abnormal concentrations that are economic and they are small and commonly difficult to recognize. How small is often ignored. Nearly 90 percent of the world's nickel comes from less than 28 mines in the Sudbury district of Ontario, Canada. A single mine at Climax, Colorado produces nearly as large a percentage of the world's molybdenum."

D. Natural resources, such as minerals, have been, and continue to be, a major source of international dispute.

Throughout history, man has squabbled over natural resources. As a hunter, he fought other tribes for wildlife resources; when he became a grazer, he quarreled over grasslands and salt licks. Later, he fought with other nations over mineral deposits from which weapons and tools were made. Today, there is serious world tension over fossil fuel resources and radioactive ores.

BASIC CONCEPT NO. 4 – Minerals are nonrenewable and deposits are exhaustible.

Suggested Activity – Social Science or Mathematics

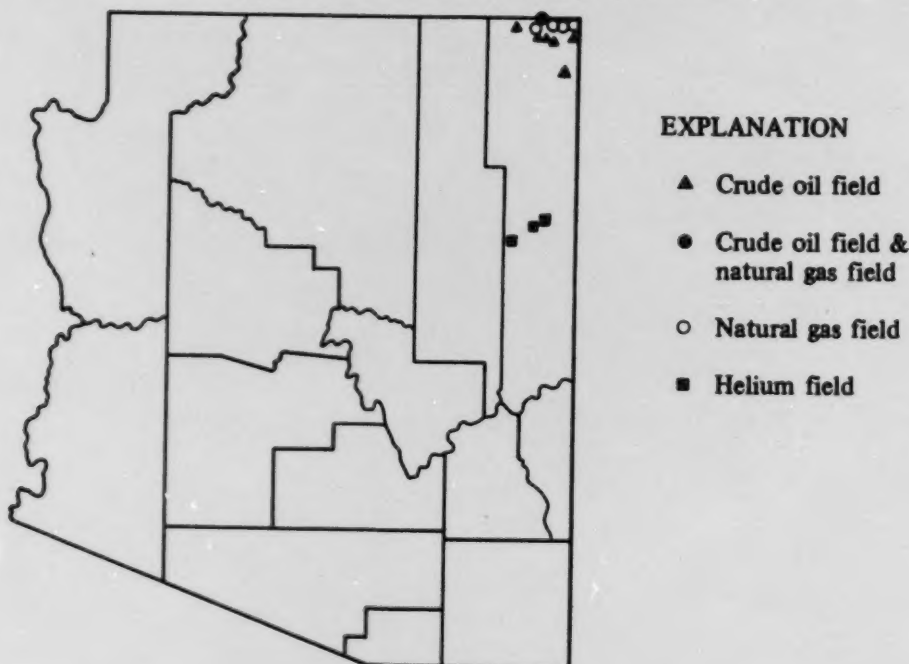
Make a map of mineral and ore deposits in Arizona. Contact the Arizona Natural Resource Department and try to find out how long these resources will last!

Understandings:

A. Mineral elements are not renewable.

Minerals are nonrenewable in the sense that they cannot be replenished.

Figure 1. Oil & Gas Production in Arizona



B. Recycling can conserve mineral supplies.

Metallic minerals, made into usable forms, are not destroyed; they can be reclaimed and reused. Today's recycling and reuse of aluminum and glass shows how careful management can extend these resources.

C. Research and technology can help conserve mineral supplies.

Research has developed knowledge which has been followed with industrial technology that is extending the supply of metals. Now it is possible, in some cases, to rework

waste dumps that were once considered of no value. As technology develops, we are able to get minerals from ore that once was of too low a grade to use. As methods of extraction improve, it will be possible to recover valuable minerals from mines deeper in the earth, from the ocean floor, from seawater itself, and, conceivably someday in the distant future, from outer space.

D. Fossil fuels are nonrenewable and cannot be recycled.

Fossil fuels cannot be recycled. These materials were made millions of years ago when thick masses of vegetation were compressed by heavy layers of land and water. They were of little use until machines demanded steam and electrical power. Now they are being used rapidly. Alternative economical sources of power must be found. Possibilities are additional power from flowing water, nuclear fission, the ocean tides, air currents, the sun, and geothermal heat. Each of these must be analyzed for their possible effects on environment and designed to avoid unbalancing reactions.



"MINERAL SUPPLIES are EXHAUSTABLE!"

BASIC CONCEPT NO. 5 – Mineral extraction changes the surface of the earth.

Suggested Activity – Social Studies

Study recent proposed federal legislation regarding strip mining. For pros and cons, read October 21, 1973 Arizona Republic, B-8.

Understandings:

A. Mining activities affect soil, plants, and wildlife.

Strip mining, particularly for coal, removes the vegetation and top soil from large areas. Little strip mining has yet occurred in Arizona, and such areas, properly reclaimed, can overcome much resource damage to soil, plants, and wildlife.

Damage is much less with open pit mining, but soil, plants, and wildlife are affected. On waste dumps, attempts have been made to establish grasses, shrubs, and trees that provide food and cover for wildlife. But such environmental repair has yet to prove its effectiveness in Arizona.



B. Land use regulations affect mining practices.

Adequate land use regulations are needed to protect other earth resources such as soil and water. Agencies responsible for land management must act to insure that all uses of earth's resources retain a high quality of living for Arizonans.

BASIC CONCEPT NO. 6 – Some minerals, during and after use, become injurious to plant and animal life.

Suggested Activity – Science

The effects of phosphate fertilizer.
Set up the experiment as follows:

Pour dissolved solution
of fertilizer over soil.



porous bottom container

aquarium with guppies
or other small fish

WATCH

Examine fish every one-half hour for evidence of change. What happened to the fish?

Understandings:

A. Mercury contamination.

Mercury is a valuable mineral. Small amounts of mercury are lost during industrial operations and settle in streams and oceans. Natural deposits of mercury also find their way into water as a result of erosion. Microorganisms consume mercury and change it to methyl mercury, an organic compound, which is later taken into, and concentrated in, some species of edible fish. Sufficient quantities become dangerous to the next consumer in the food chain, which in some instances is man. Research into animal and man's tolerance limits for mercury continues; it is not yet complete.

B. Burning fossil fuels results in emissions into the air.

The unburned portion of fossil fuels is exhausted into the atmosphere. In some large cities, during periods of heavy traffic, carbon monoxide content in the air may reach critical amounts for those exposed to exhaust fumes for long periods, such as policemen and taxi drivers.

C. Nuclear wastes create problems.

Wastes from nuclear fuels are radioactive and no safe technique of disposal or storage of these wastes has yet been developed.

SUGGESTIONS AND ACTIVITIES

Mathematics

A. SAVE THE CANS

Have the students save aluminum cans. Each 12-ounce can is worth about one-half cent. Count the money the children earned. (Primary)

B. LITTER-LITTER

Collect litter from a vacant lot. Classify all the litter into categories. Count the separate items of litter. Which category has the most? Which category the least? (Primary)

C. HOW MUCH SAND?

How many cups of sand equal a quart of sand? How much does a quart of sand weigh? (Primary)

D. COPPER AND ORE

There are approximately 500 pounds of copper wiring and tubing in the average home. If a mining company can recover 12 pounds of copper from a ton of ore and has to move 2 tons of waste rock for every ton of ore, how many pounds of material have to be moved for the copper in one home? (Intermediate)

E. MINERAL CRYSTALS

What geometric shapes are represented in the crystalline structure of minerals? (Intermediate)

F. ESSENTIAL MINERALS

How many and how much of each of the various essential minerals does the average size person consume in a year? (Consult the minimum average daily requirements on various food labels.) (Intermediate)

G. GARBAGE RECORD

Check your family's garbage. Keep careful records. How many pounds of glass is each member of the family responsible for each month? Tin cans? Paper? Etc.? How much

for the families of everybody in the class for the month? Average out the total and compute the amount of garbage disposed of in the United States in one month. Check your figures with newspaper accounts. (Intermediate)

H. HOW MUCH GASOLINE?

If an automobile gets 15 miles per gallon and the driver averages 1,000 miles per month, how much gasoline is used in a year? (Intermediate)

I. HAULING ORE

If a modern ore haulage truck carries 100 tons per load 1 mile each way to the crusher and can make 5 trips an hour, how long will it take a burro that can carry 200 pounds per load at 2 miles per hour to equal the total the truck can haul in an 8-hour shift? How much pollution will each be responsible for? How much has the improvement in hauling equipment affected mining and our use of minerals? (Junior High)

J. EARTH'S HEAT

Calculate the temperature beneath the surface of the earth in some of the world's famous "tunnel" mines. The temperature increases approximately 30 degrees Celcius per kilometer. What effects does the temperature have on the miners working in these mines? What has been done to help miners while working underground? What laws apply to mining safety standards? Who has the most interest in protecting miners? Unions, mining companies, or State/Federal agencies? (Junior High)

K. CRYSTALS AGAIN

Identify the mineral in several rocks. This is done by examining the crystal structure, the hardness, etc. (Junior High)

L. AND AGAIN!

Examine several different minerals. Draw the crystalline structure of each. (Junior High)

M. CALCULATE THE BTU's

Calculate the amount of BTU's used in Arizona yearly. These figures are available from Arizona Public Service Company. In 1975, Arizona used 164 billion cubic feet of natural gas. (1,000 BTU = 1 cu. ft.) (Junior High)

N. READ YOUR METER

Learn how to read an electric meter. How much electricity does each student's family use each day? Each month? Each year? Now have them calculate the amount of coal used to generate that amount of electricity. The coal used in the Four Corners' power plants gets, on the average, about 8500 BTU's per pound of coal. If 1 kilowatt hour (KWH) equals .0003 BTU's, how many pounds of coal are used to electrify all the students' homes for a month. Remember, the conversion of coal to electricity is about one-third, so multiply your answer by 3. Finally, if 1 cubic foot weighs between 75 to 94 pounds (average of 85 pounds), how many cubic feet are needed to store the coal used by you each month. Calculate the storage space for your class for the month and find a room or building that could store that much coal. Does the utility bill each family receives correspond to the amount of electricity recorded on the meter? What could cause the difference between readings? (High School)

O. THE DEMOGRAPHIC QUOTIENT

In 1969 a demographic quotient (Q) was developed by Cloud Odum (1969) to relate the quality of life to the supplies of various nonrenewable natural resources. When the DQ value goes down, so does the quality of life. Q equals the total supply of a resource divided by the product of the population density (number of people per some unit of area) and per capita consumption of the resource. Calculate and graph Q for your classroom (the world) for some hypothetical resource (sheets of paper). Vary class size (density), then, the use of paper by each student (consumption), such as 1 sheet per person per day, 2 sheets, and so on. What happens to Q? Which affects Q the most? How does Q change if you were able to recycle 60% of the paper each week? How about a program of population control (no new students are added to the classroom)? Discuss and calculate Q for some mineral resources found in nature such as chromium, gold, lithium, etc., based on current population data. (High School)

Language Arts

A. OPPOSITE WORDS

Make a list of opposite words—five pairs (i.e., good—bad, quiet—noisy). Take the children on a walk around the building. Have them list what things in the environment remind them of the words. (Primary)

B. FEELIE BAG

Make a "feelie bag." Place in it different objects. Have the children guess which ones were made from a mineral substance. (Primary)

C. COLLECT REFUSE

Take the children on a walk to a vacant lot or around the school. Collect all the refuse. Have the children describe what they found and what the things were made from. (Primary)

D. DESCRIBE IT

Write a descriptive paragraph. Provide a bag filled with familiar objects made from rocks and minerals. Include metal objects or mineral-based construction products. The number of possible items seems almost unlimited. Blindfold each member of the class and have each reach into the bag and orally describe one or more of the hidden objects. Then have each student write a single descriptive paragraph about one of the objects touched. Finally, have each student identify the item described.

(Intermediate)

E. DIFFERENT THINGS

List as many items as you can that are made from steel and iron. Include things from your home and school. Also, make a list of things made of plastic, rubber, and fiberglass. What items from your first list could be replaced by materials on your second list? What items from your first list do you think *will* be made from plastic, rubber, and fiberglass? What things today *are* being made from these materials? Try this activity for some other minerals such as copper or aluminum. (HINT: Examine an older automobile and compare various parts with those on new cars.)

(Intermediate)

F. SEE, TELL, AND CHANGE IT

Obtain three groups of photographs illustrating: (1) an undisturbed environment such as a wilderness, stream, or grassland; (2) an area manipulated by man such as farmlands, residential areas, mines, or highways; and (3) photos of adverse environmental conditions caused by man. Include erosion on farmland, polluted air, or overcrowded cities. Divide the class into equal-sized teams and have each group orally describe and characterize a set of photographs (one set at a time) with reference to the location, degree of man's influence, age, and the reasons for the conditions illustrated (especially photo sets 2 and 3). Have each student write a one-page report regarding alternative management decisions which could have been done to either prevent, relieve, or continue the conditions shown. Remember to bring out the needs of man and his use of the environment for natural resources.

(Junior High)

G. MINERALS AND YOU

Follow yourself through a normal day. Keep a journal on what minerals affect your life, and how.

(Intermediate)

H. MINERAL NEWS AND ARIZONA

Write objective news stories about the opening of a new copper mine, the discovery of oil in Arizona, development of a new process using waste materials, how tourism affects the minerals industry.

1. Write feature stories about an Arizona ghost town, an old prospector, collecting minerals, a scrap drive, conservation of mineral resources.
2. Write editorials about the energy crisis, reclaiming mined land, importing needed minerals, legislation affecting minerals exploration. (Research carefully.)
3. Write letters to the editor about concern for development of mineral resources, what should be done, what should not be done, why.

(Intermediate, Junior High, High School)

I. THE SILICON STORY

Write an original story about a man who comes from a planet that has no oxygen. All the oxygen has been replaced by silicon. Research the properties of silicon in chemical reactions. Relate to earth life.

(Junior High)

J. READ A BOOK

Consult your library for novels, poetry, and biographical works of the period in U. S. History when mineral exploration was responsible for the development of the West.

Service Poems — Poet Robert Service wrote many pieces on the sourdoughs of Alaska. Learn and recite one.

Mining Stories — Jack London, Bret Harte, Samuel Clemens (Mark Twain) all wrote of miners and mining camps. Read and report on a story by one of them.

(Junior High)

K. WRITE A HEADLINE

Write an imaginary headline for a newspaper some years into the future. Discuss industrial development in the community based upon available resources. As part of the story, tell of several companies (even industries) which went out of business or came into being because their source of raw materials ran out.

(Junior High)

L. ORIGINS

Pick any unlikely object—lipstick, perfume, peanut brittle, electricity, stockings—and trace its origin back to minerals. Write a report describing this.

(Junior High)

M. WRITE A HAIKU POEM

Describe a rock, mineral, mineral product, or mining activity by writing a three-line, 17 syllable Haiku poem. In the first line use 5 syllables; in the second, 7 syllables; and in the third, 5 syllables. For example:

Prospectors long dream
And thoughts of happiness loom
Beneath mountain pools

Go ahead, be creative!

(Junior High, High School)

N. CREATE A CINQUAIN POEM

This type of poem involves five lines: line 1, name a mineral or mineral product; line 2, make an abstract description of the object in line 1; line 3, make a physical description of the object; line 4, provide another abstract description; and finally, line 5, a single word synonym for the word in line 1. For example:

Coal
Frozen, heat
Shiny, black, heavy
Shining bright while casting shadows
Fuel

(Junior High, High School)

O. FUTURE LIFE-STYLES

Assign some selected readings about alternative futures (science fiction and nonfictional selections). What assumptions and conditions about resource supplies and their derived products (steel, iron, energy, or concrete) were made? Use these readings to initiate discussions about past and future life-styles. (High School)

P. DEBATE

Organize debating teams and assign subjects:

1. Should America depend on foreign sources for oil, copper, chromium, (others)?
2. Create a hypothetical area: rich in beautiful scenery and wildlife but equally rich in a badly needed mineral. Should the scenery be sacrificed for the mineral and all the jobs that would be created? (High School)

Q. ALUMINUM REPLACES STEEL

Discuss how aluminum is replacing steel as a material and what are the economic effects of such a conversion. Consider the implications on other industries such as mining and energy. What natural resource was important? What were the economic and social conditions? (High School)

R. ARIZONA PLACE NAMES

Select an Arizona town or city from *Arizona Place Names*. What nonrenewable natural resource was responsible for the development of the city? What social and cultural factors have been affected over the years as the resources on which the city's economy was based have been removed or replaced by other resources? (High School)

Fine Arts

A. A POSTER

Make a poster about pollution.

(Primary)

B. PAINT A ROCK

Paint rocks with different designs or pictures, including pets.

(Primary)

C. ROCK COLLECTION

Bring different rocks to class. As a class, make a collage with the rocks.

(Primary)

D. FUN WITH PEBBLES

All that is needed is a choice of pebbles, pipe cleaners, poster paint, epoxy glue, felt, wire, strawflowers, felt-tipped markers, and plenty of imagination.

Gather stones in various shapes. Wash stones clean and let dry. Examine stones from all sides. You will find that they suggest faces of animals or odd creatures—owls, penguins, frogs, etc. Larger stones with flat sides make good bodies; smaller stones in odd shapes make good heads for animals. Use natural imperfections for the lines of mouth, eyes, nose.

All features may be painted on the stone head—or just the mouth—as your imagination suggests. Or use felt, leather, or glue. It is better to merely suggest features.

Glue on smaller stones. Hold parts until they set. Glue a piece of felt on bottom of creature to protect table. (Primary)

E. THE IMAGINARY MOUNTAIN

Use a small rock or mineral sample as a model and draw it to look like a huge boulder or range of mountains. Imagine you live there. Where would you live? What would you do? (Primary)

F. SAND PAINTING

Make a sand painting using different colored sand. Have the students try different Indian designs, realistic paintings, and modern art techniques. (Intermediate)

G. MAKE A POSTER

Create a poster with a theme about our limited natural resources. (Intermediate)

H. THE LONELY CAN

Draw picture of a "sad" mine or "lonely" discarded can or bottle. Where would they like to be? What would they rather be doing? Are they proud or sad at their fate? Be creative! (Intermediate)

I. CRYSTAL MODEL

With the aid of a hand lens, make a three-dimensional model of a mineral crystal. Emphasize the crystal's structure, color, and texture. Compare your model with models of different crystals. What do they have in common? (Intermediate)

J. LABEL IT

Remove labels or advertising from empty cans or bottles and replace them with new designs which emphasize the containers' contents and how the containers could be reused. Also develop advertising which concerns the type of materials used to make the containers. (Intermediate, Junior High, High School)

K. FROM THE EARTH

Make a drawing of your room at home, school room, or any other indoor place which has meaning for you. Emphasize, through the use of color, texture, or shading, those things found there that come from the earth. This could include energy. (Junior High)

L. ROCK COLLAGE

Make a collage using rubbings made of various types of rocks and minerals. Try to simulate the rocks' colors by using colored chalk or crayons. Use rubbings of man-made surfaces to accent and contrast natural textures. (Junior High)

M. OLD FAVORITES

1. What songs did the "Forty-Niners" in the California Gold Rush of 1849 sing? Are any of them still popular? Research the information and have students sing the songs in class.
2. Learn and sing "Oh My Darling Clementine" (and others).
3. Are there any more contemporary "mining" songs like "Sixteen Tons" or "Big John"?
(Junior High, High School)

N THE PIT

Design and build a plaster of paris model of an open-pit mine.

(Junior High)

O. TEXTURED OILS

Using different colored minerals, grind them, mix them with oils, make paint for a painting.
(Junior High, High School)

P. MAKE A SAND PAINTING

Using different colored minerals, grind them to sand consistency for sand painting.
(Junior High, High School)

Q. MAKE JEWELRY

Use a stone tumbler to polish small rocks or minerals; cement them to loops or clasps for earrings, bracelets, or necklaces.
(Junior High, High School)

R. CUT AND POLISH

With lapidary equipment, cut and polish semiprecious minerals for jewelry making.
(Junior High, High School)

S. THE OLD WEST

Read a poem or short story or listen to a record about the "old west" mining towns, mining life, and success stories about miners. Interpret the story's theme and mood in creative dramatics or in a drawing emphasizing color, shape, texture, and various thicknesses of lines.
(Junior High, High School)

T. BLOCK IT

Make a block print drawing using a 1/4-inch piece of acetate sheeting. As a theme, emphasize the importance of mining on Arizona's history and future. First, draw a picture on paper. Using a sharp knife, scissor's point, or compass, reproduce the drawing on the acetate sheet. Ink the sheet, then wipe the ink from all of the flat surfaces being careful not to remove ink from the etched lines. Place a piece of damp (not wet) paper over the sheet and tape the edges making the unit a "packet." Press the "packet" using a rolling pin or put the entire "packet" in the wringer of a washing machine. The result should be a fine-lined reproduction of the original drawing. You can also leave ink on some of the flat surfaces to create interesting textures and shading.

(High School)

U. THE FAMILY ROCK

Trace back your family coat of arms in a genealogy book or history book. Obtain a flat river rock that is oval or round and paint your coat of arms on the rock. Each child will now have his family rock. Learn the symbols and history that are found in the coat of arms.

Source: Arizona

A. RECYCLEMENT

Lead a discussion of the meaning of recyclement. Ask students to bring to class articles, pictures, or models of things in our environment which can be and have been recycled. Some examples are junked cars to scrap metal, used paper to clean newsprint, bottles to new glass containers, etc. Why do both rich and poor societies need to recycle the results of the technology? What does the term "planned obsolescence" mean? How can we encourage and take advantage of our "trade in" practices? What things have states or countries done to speed up the recyclement process?

(Intermediate)

B. OLD ARIZONA

Describe the various stages in the history of the many ghost towns in Arizona. What made the people come in the first place? How many lived there at its peak? What is the youngest ghost town in Arizona? The oldest? How did the people earn their living? Where did they get their food? What was the chief mode of transportation? What minorities lived there? (Remember: Englishmen, Slovaks, Italians, Germans, Chinese, Mexicans, etc., were all considered "minorities" at one time.) Why did everyone leave? How old was your father or grandfather when the town was abandoned?

(Junior High, High School)

C. OUR MODERN JUNK

Display examples of our modern, throwaway containers such as soft drink bottles, cans, or paper. Have the class discuss what happens to these articles after they are discarded? Emphasize how nature recycles continuously and materials are reused in the environment. How many times does man reuse different materials? Why do many of our containers come in a nonreusable form? What materials does man use for containers? Do these materials readily return to their original condition?

(Junior High, High School)

D. THE COUNTRY STORE

Set up a game where each country can bargain or trade with one another for minerals and petroleum resources. Assign two or three students to represent a country. Each group will receive money based upon the national wealth of that country and cards or tokens representing how much of each mineral resource they own. The object is to define some goals or needs their country has and then to play so as to not deplete their supplies. Consult encyclopedias or other reference books for the gross national products and mineral holdings of some 15 to 20 countries around the world. How similar are the class-defined goals to the goals of "their" countries as expressed in current newspapers or magazines? How have poor countries dealt with rich countries in regard to their mineral resources? (See list on next page)

(Junior High, High School)

E. LAND-USE PLANNING

Is land-use planning needed? Should an agency set aside certain lands for grazing, timber, home development, mining, etc., without first determining if, for instance, the land has needed minerals under the surface? Which resources (i.e., grass, timber, water, or minerals) should take precedence in their exploration? What have been the resource policies in the past? Are they correct? Explain your feelings?

(Junior High, High School)

F. WORKER SAFETY

The health and safety of workers is a vital concern in not only the minerals' industry, but all other industry as well. Who should be responsible? The federal government? The state government? The company? Labor unions? What problems are involved? Who has the most to lose?

(Junior High, High School)

G. AMERICAN INDUSTRY

Have each student select a major American industry and list the various types of minerals required to sustain that industry. Examples would include farming, aircraft, and electronics. How have the requirements for the industries changed over the years?

(Junior High)

COUNTRY	GNP (in billions)	MOST COMMON MINERALS
United States	900	Oil, gas, bauxite, building stone, copper, lead, phosphorous, zinc, potash, uranium
USSR	400	Tin, coal, natural gas, petroleum, iron, manganese, chromium, nickel, lead, zinc, copper
Japan	200	Lead, coal, copper, zinc
West Germany	200	Lead, coal, uranium, zinc, potash, iron
France	200	Iron, potash, uranium, bauxite, coal, gypsum
Great Britain	100	Limestone, salt, sand, gravel, coal, iron, chalk, clay
China	85	Salt, tin, tungsten, coal, iron, manganese
Italy	75	Asbestos, bauxite, marble, mercury, sulfur, zinc
Canada	66	Copper, aluminum, iron, lead, nickel, gold, zinc, petroleum, uranium, coal
India	44	Magnesite, salt, copper, sulfur, coal, iron, chromite, gypsum, limestone
Poland	39	Coal, lead, zinc, iron, sulfur, salt, potassium
East Germany	32	Iron, coal
Australia	29	Lead, copper, zinc, iron, silver, gold, petroleum, coal
Brazil	29	Iron, manganese, gold, diamond
Czechoslovakia	27	Copper, iron, limestone, petroleum, coal, clay, manganese
Mexico	26	Coal, copper, fluorspar, iron, tin, zinc, lead, natural gas, petroleum, manganese
Sweden	26	Copper, gold, iron, lead, uranium, zinc
Netherlands	25	Natural gas, salt, petroleum
Spain	25	Sulfur, iron, salt, coal, copper, mercury
Belgium	20	Coal, copper, lead, zinc

Research GNP and Resource figures for various Middle-eastern countries.

H. MAN AND MINERALS

List the minerals primitive man used? How did he use them? Where did he get them? How did he get them? Read about various Indian tribes and how they traded for minerals and rocks. Compare tribes with the minerals found in their local regions. How far did they travel to obtain them? (Junior High, High School)

I. STRIP MINING

Discuss some specific environmental problems resulting from "strip mining." What are the reasons given for this type of mining? Do the end results justify the use of this technique? What are the benefits to this method? What solutions can be offered to reclaim strip-mined land? What are the problems with these solutions? (High School)

J. LIMITS OF INDUSTRIAL PRODUCTION

Have students develop tables of resource use based on the needs of our largest industries, contrast existing available resources with predicted future needs. Several representative industries include automobile, petroleum, chemical, and paper. Do we need all the commodities we presently demand? Explain. How must we reconsider "planned obsolescence" and other characteristics of industrial operations? Discuss the physical limits of resource utilization which may begin to affect industrial production? Why must we establish priorities for resource use? (High School)

K. THE POLITICAL WORLD

In America, we use more minerals than we mine domestically. How does this affect our balance of trade? The value of the dollar? The security of our nation? What steps have been taken to resolve balance of trade problems? Have our methods changed over the years? Explain. How can the problems be solved? By using less minerals? By increasing production? By securing foreign sources? What other problems do these "solutions" create? (High School)

L. SHOULD WE MINE?

There is evidence of good mineralization on the Cabeza Prieta Game Range and Luke and Williams Air Force Base Gunnery Ranges in the southwest part of Arizona between Ajo and Yuma. It was withdrawn in 1939 from public entry before modern methods of prospecting and mining were developed. Should prospecting be allowed there now? If not now, when? (Junior High, High School)

M. WILDERNESS AND MINERALS

Should planning agencies set aside certain lands for housing development without first determining whether there is an adequate supply of water? Read the Wilderness Act of 1964. What does it say about mineral resources? Who stands to benefit from the law? What was Congress' feeling about minerals at the time the bill passed? Has their perception changed since then? (See Table 1 on next page) (High School)

TABLE 1

Varieties and Values of Mineral Production in Arizona in 1966¹

Commodity	Quantity	Value	Percent of total value
Clays (exclusive of bentonite) short tons	89,000	\$ 121,000	0.02
Copper (recoverable) do	739,569	535,004,000	86.00
Diatomite do	1,353	36,000	.01
Gem Stones ²		120,000	.02
Gold (recoverable) troy ounces	142,528	4,988,000	.80
Gypsum short tons	75,000	394,000	.06
Lead (recoverable) do	5,211	1,575,000	.25
Lime do	218,000	3,721,000	.60
Mercury 76-pound flasks	363	160,000	.03
Molybdenum (in concentrate) pounds	10,161,000	17,812,000	2.86
Natural gas cubic feet	3,161,000,000	436,000	.07
Petroleum (crude) barrels	132,000	370,000	.06
Pumice short tons	1,103,000	1,674,000	.27
Sand and gravel do	18,730,000	20,448,000	3.29
Silver (recoverable) troy ounces	6,339,000	8,196,000	1.32
Stone short tons	2,271,000	4,091,000	.66
Tungsten (ore and concentrate, 60 percent WO ₃) . . . do	2	5,000	.01
Uranium (recoverable U ₃ O ₈) pounds	437,000	3,492,000	.56
Vanadium (recoverable) ²		454,000	.07
Zinc (recoverable) short tons	15,985	4,636,000	.74
Undistributed ³		14,347,000	2.31
Total		\$622,079,000	

¹Compiled from Larson and Henkes (1967, p. 1, and 1968, p. 2) and D'Amico (1967, p. 113).

²Not available

³Individual quantities and/or values have not been cited to avoid disclosure of confidential data. Included are asbestos, cement, bentonite, feldspar, helium, iron ore, mica, perlite, and pyrites.

N. HOW DO WE USE THEM?

Here is a list of the principal minerals mined in the state in order of their relative dollar value in 1972: copper, molybdenum, sand and gravel, silver, stone, gold, lime, petroleum, zinc, pumice, lead, gem stones, natural gas; and a number of others not in order of value: asbestos, cement clays, coal, diatomite, feldspar, fluorspar, gypsum, helium, iron, mica, perlite, pyrites, and tungsten. How many do you use? How do you use them? Make a list and compare your results. Which minerals are becoming more rare? How have your uses or society's uses changed over time? (High School)

O. WAR AND MINERALS

What minerals are most necessary to carry on a war? Read historical reports concerning a major war. What minerals contributed to the initiation, continuance, and final outcome? What minerals or mineral products (or lack of) contributed most to victory and defeat? What factors concerning mineral resources seem to directly or indirectly contribute to hostilities in the world today? (See Table 2 on the next page)

(High School)

P. MINING SIMULATION

Set up a hypothetical problem about Arizona concerning mining. Examples could include: (1) a new copper deposit has been discovered in Organ Pipe National Monument; (2) a Supreme Court decision barring mines from using ground water if such use depletes water supplies from local users; or (3) various county governments have moved to significantly increase taxes on mines as a means to increase local revenues. Assign groups of students to particular roles to play, such as state legislators (running for office), members of conservation groups, tax assessors, farm organization members, or copper company executives. Have each student determine the implications of the situation for his/her role and have the students (as a group) come up with three or four objectives they would like to see happen. Have each group plan a course of action to resolve the situation. Finally, conduct a mock hearing (convened by the Governor) to present the various points of view. Develop a method of scoring in which the effectiveness of each group is evaluated. A point to consider could be how well each group presented the facts as they saw them, how much compromising was done, which group was most effective in leading the groups to their objective.

(High School)

Q. THE NUCLEAR ALTERNATIVE

Set a situation in which a utility company wishes to build a nuclear power plant near your home. Have students debate the proposal, insuring that as many students as possible have the chance to play the role of both the company and the public. The debate should encompass both preliminary and final negotiations along with making the decision. What are the arguments for and against such a proposal? How can man keep pace with increased energy demands? How can decisions on such vital issues, in light of increased resistance by the public, be made? What alternatives are available to the company, local communities, individual citizens, and society? (High School)

**Dependence on Foreign Minerals in World War II and 1975
By Percent**

Mineral	Percent Imported World War II	Percent Imported 1975	Source
Antimony	100.0	94.0	China, Mexico, Bolivia, Peru, Indonesia
Bauxite (Aluminum)	18.1	85.0	Surinam, British Guiana, Jamaica
Beryl	90.6	90.0	Brazil, India, Argentina, Africa
Asbestos (Strategic)	100.0	100.0	Belgium Congo, Rhodesia, Canada, South Africa, South Rhodesia, Turkey, Cuba
Chrome	89.6	100.0	New Caledonia, Philippines
Cobalt	85.6	90.0	Belgian Congo, Rhodesia, Cuba
Corundum	100.0	100.0	South Africa
Copper	37.6	65.0	Chile, North Rhodesia, Belgium Congo, Canada
Diamond (Industrial)	100.0	100.0	Congo, Angola, South Africa, Brazil
Fluorspar	2.0	50.0	Mexico, Africa
Graphite	100.0	100.0	Madagascar, Ceylon
Iron Ore	2.0	35-45	Venezuela, Canada
Lead	44.2	70.0	Mexico, Peru, Australia, Canada
Manganese	85.5	80.0	India, Africa, Brazil, Cuba
Mercury	43.2	80.0	Italy, Spain, Mexico, Canada
Mica (Strategic)	88.0	95.0	India, Brazil
Quartz (Radio)	99.0	100.0	Brazil
Nickel	100.0	100.0	Canada, Cuba, New Caledonia, Cuba
Petroleum	0.0	50.0	Venezuela, Middle East, Canada
Columbium-Tantalum	99.0	99.0	Brazil, Congo, Nigeria
Sulfur	0.0	50.0	Canada, Mexico, Europe
Tin	100.0	100.0	Malaya, Indonesia, Bolivia, Congo
Titanium	26.0	80.0	Canada, India, Norway
Vanadium	32.4	25.0	Peru
Tungsten	61.1	70.0	China, Bolivia, Brazil, Portugal
Zinc	36.7	60.0	Mexico, Peru, Australia, Canada

From "Our Future Dependence on Foreign Minerals" by Alan M. Bateman. *The Annals*, Vol. 281, 1952: pp. 25-32.

R. OUR BUILDING MATERIAL

Have students list the major building materials used in your local community. Have them identify examples of structures constructed from each material. Assign an approximate date of construction and source of the materials used. Collect samples of the materials (drywall, concrete, mortar, adobe, and stone). Test for the durability to heat, water action, and wind for these materials. Research these building materials at your library or consult local building contractors. What materials are imported into your area? Which is most commonly used in your area? Your region of the country? What effect does the climate have on these materials? Are some more durable than others? List the strengths and weaknesses of each material. What suggestions could you make as to alternative materials?

(High School)

S. MINERALS AND FRIENDS

Based upon the above information, are we more or less dependent on foreign sources of raw materials? Which countries do you think would trade with the United States in time of war? What minerals would the U. S. run short of? What products come from these minerals? What about nuclear fuels such as Uranium, Thorium, and Radium?

(High School)

Science

A. GROW CRYSTALS

Add 2 ounces of alum to 1/2 cup of water. Heat the mixture while stirring until all of the alum has dissolved. Pour the liquid into a small jar and hang a paper clip by a string into the jar. Let the jar cool. Describe and/or illustrate what happens. Do the same with other materials such as sugar, salt, or Epsom salts. As a variation, make two solutions of each and subject the two solutions to different conditions such as temperature. Compare the results to actual mineral samples. Hypothesize what conditions were present when these samples were formed.

(Primary, Intermediate)

B. MAKE A COLLECTION

Make a rock or mineral collection. Classify the rocks according to color, how they feel, and how hard they are.

(Primary, Intermediate)

C. TRACE THE ORIGIN

Choose ten things with the teacher and trace their origin to the soil.

(Primary, Intermediate)

D. COLLECT ARIZONA MINERALS

Arizona is rich in a multitude of minerals. Get a copy of a mineral handbook from the Arizona Department of Mineral Resources or the Arizona Bureau of Mines and start a collection of Arizona minerals. A collection is organized, cataloged, and appraised. A box of pretty rocks is called an accumulation. (Intermediate, Junior High)

E. IRON FILINGS

With a gold pan, wash some black sand from a dry wash. Dry it and put a magnet in it. What happens? Why? What geological phenomena does the gold pan simulate? What evidence of this do you see in streams and rivers? (Intermediate)

F. CEMETERY STONES

Survey a cemetery. Identify the type of rock used for headstones. Is the writing on each clear? Why not? (Intermediate, Junior High)

G. SEISMOGRAPH

Build a seismograph. You will need:

- a brick
- sticks and boards
- nails and a hammer
- pencil and tape
- string and paper

What is a Richter Scale?

(Intermediate, Junior High)

H. MAN'S HEAT

List different ways man heats his home. What is the origin of each?

(Intermediate)

I. MINERAL CHARACTERISTICS

With a number of rocks or minerals, have the class sort them according to their general physical characteristics such as color, texture, density, and hardness. Have the class come up with names for each group of rocks developed. Second, with a collection of minerals, conduct tests to determine what the mineral is. Consult the following table for tests and mineral characteristics. (Junior High)

Mineral	Color	Crystal	Streak	Hardness	Specific Gravity
Copper	Copper-Red	4-sided	Metallic	2.5	8.9
Azurite	Azure Blue	Small Crystals	Blue	4	4.0
Malachite	Dark Green	Rare	Light Green	3.5	4.0
Chrysocolla	Light Blue	Never	White	2.4	2.1
Silver	Silvery Gray	Rarely	Gray Black	2.5	10.5
Cinnabar	Dark Red	Rare	Red	2.5	8.0
Gold	Golden Yellow	Rare	Golden Yellow	2.5	19.3

Hardness:

- 1 will not scratch any other mineral (Talc)
- 2 scratches fingernail
- 3 scratched by a penny
- 4 scratches a penny
- 5 scratches glass
- 6 scratches a good knife
- 7 scratches a steel file

J. **HOMEMAKING MINERALS**

In sewing, what materials are derived from minerals? What minerals? How do we use minerals to color or dye fabrics? Make a dye from a mineral such as copper, sulfur, or hematite, etc..
(Junior High, High School)

K. **START A FIRE**

Consult a Boy Scout or Girl Scout manual on how to start a fire using flint, jasper, quartz, or agate and a piece of high carbon steel. Strike the steel on the mineral with a glancing blow. This should give off sparks. Try to aim the sparks in the direction of some charred cotton, rope, or other easily combustible material. What other mineral resource did the American Indians use? Research some of these and try to duplicate these uses. An example would be the use of obsidian, flint, or other materials for making arrowheads and spear points or the use of rocks as grinding tools.

(Intermediate, Junior High)

L. **MAKE SOME GLASS**

Mix 1 teaspoon of clean quartz sand, 1 teaspoon of sodium carbonate, and 1 teaspoon of lead dioxide in a metal can. Set the can in a hot fire, kiln, or furnace for 1 hour. Pour the contents out onto several thicknesses of cardboard or paper. How does this method compare with commercial glass-making operations? What chemical reactions take place while making glass?
(Junior High, High School)

M. **WHAT WE NEED**

Consult a book on nutrition. Find tables on the Recommended Daily Allowances (RDA). What are the recommendations for iron, phosphorous, magnesium, calcium, etc. Consult the food packages in your home, such as a cereal box, candy bar, or a can of corn. How much of each mineral does each food supply? Using conversion tables, calculate your daily intake of these minerals. Do mineral requirements change as you grow older? Which minerals are needed by adults and children? What effect does cooking have on the minerals in food? What are the sources of these minerals? Follow the path of these minerals through the environment. Draw a diagram of the mineral cycle involved.
(Junior High, High School)

N. **KITCHEN MINERALS**

What common minerals does the housewife use in her kitchen every day? In the rest of the home? What energy sources power these devices? How has the use of minerals or mineral products changed over the past few years? What materials have been replaced? In your opinion, what are the trends in the types of mineral products that you see in kitchen equipment?
(Junior High)

O. OUR NECESSARY MINERALS

What minerals are essential to a balanced diet? How many minerals do our bodies contain? Why is iron necessary? Consult the nutritional information on package labels for the types of minerals present in food. Where do these materials come from? How are they processed? What does cooking do to these minerals? How are these minerals recycled back into the environment?
(Junior High, High School)

P. FOOD MINERAL CONTENT

Determine the mineral content of some foods (cereal, bread, or candy). Select one mineral and make a diagram which will illustrate its cycle through the environment. Why is life dependent upon the cycling of materials? How does man effect the cycling process? In what ways does man attempt to maintain or encourage the cycling of materials? What else must man do in this regard to sustain his own existence?
(Junior High, High School)

Q. DESIGN A BUILDING

What materials did you use to design a building? Where did the materials come from?
(Junior High)

R. LEACHING COPPER

Acquire a sample of one of the copper oxide ores (cuprite, chrysocolla, malachite, azurite), crush it to a sand consistency, mix it in a glass beaker with sulfuric (or some other) acid in solution with water (dilute 5%). This process is called leaching—dissolving the copper from the ore with acid. The resulting solution is called copper sulfate. Drain it from the beaker into another glass container and soak pieces of iron in it. (Be sure the paper and tin are removed from the shredded "Tin" cans.) The iron replaces the copper in solution leaving a reddish-brown residue that is about 90% copper. This is called precipitation. This "cement copper" (if it dries, it hardens) may be "smelted" or fire-refined with a Bunsen burner and blow pipe.
(High School)

S. MELTING METAL

Get a bottle of mercury, a piece of lead, iron, etc. From tables, what are the melting points of mercury, lead, copper, iron, etc.? At what temperature do these materials vaporize? Compare them to water. How do we use the temperature characteristics of these materials for man's use? State examples.
(High School)

T. ALTERNATING ENERGY AND THERMODYNAMICS

Read about the first two Laws of Thermodynamics. What implications do these laws have as related to various alternative sources of energy such as power from the sun, wind, and tides? What must be done to utilize these types of energy? What implications do they have on our economy? Our life-styles? Our culture?
(High School)

Vocational

A. BUILD A CABIN

Build a model of a prospector's cabin. Research the materials that were used and why.
Build to scale. (Junior High)

B. PROSPECTOR'S POKE

In leathercraft, use a lightweight leather to make a prospector's poke.
(Intermediate, Junior High)

C. MAKE A WASHING PAN

In metal shop, make a gold-washing pan. Learn how to use it. Vary the design of the pan and test it for effectiveness. How does the pan work? (High School)

VOCABULARY

amphiboles — A group of minerals containing varying ratios of different silicates. They tend to be fibrous or show prismatic cleavage.

basalt — An igneous rock found near volcanoes—usually fine grained, dark, and heavy. It consists of many small crystals made up of plagioclase and pyroxene. Its overall composition is a calcium sodium feldspar.

basaltic rock — (1) A dark, heavy, and hard-colored rock made of tiny mineral grains. Basalt is crystallized lava. The grains it is made of are crystals made chiefly of plagioclase and pyroxene. Sometimes it also has calcite in little pockets. (2) A class of igneous rock formed by volcanoes.

B.T.U. — British Thermal Unit. The quantity of heat necessary to raise the temperature of one pound of water one degree.

chromium — A hard, blue-white metal, with the symbol "CR." It is primarily used in the manufacturing of steel alloys.

conglomerates — A sedimentary rock containing rounded fragments varying anywhere from pebbles to boulders.

continents — Large land masses of the earth, such as Africa, Asia, North America, South America, Australia.

crystalline — Material made up of crystal.

demographic quotient — Relating to the dynamic balance of a population with regard to density and capacity for expansion or decline.

diameter — (1) A straight line passing through the center of a circle, from one side to another. (2) A unit of magnification of microscopic and telescopic observation.

diatomite — An earthy material made up mainly of diatom shells. Its uses are as a polishing powder and for manufacturing explosives as well as many other things.

erosion — The wearing away of earth or rock. The main causes of erosion are the actions of air and water, and changes in the earth's temperature.

fossils — An imprint left by once-living organisms preserved in rock.

garnet — A semi-precious silicate mineral of the general formula SiO_3 .

geological — Referring to the earth's crust or its history.

granitic rock — Metamorphic rocks generally consisting of quartz, feldspar, and mica.

igneous rocks — Rocks formed by cooling of volcanic magma. An example is obsidian.

inorganic — Not living; composed of matter that isn't animal or vegetable.

- kilometer* – A unit of measure equal to 1,000 meters, or around 5/8 of a mile.
- kilowatt* – A unit of electrical power that equals 1,000 watts.
- mercury* – A heavy metallic element which is liquid at normal temperatures.
- metallic* – Having the nature or properties of metal.
- metamorphic rock* – The term comes from a Greek word meaning “change of form.” Rocks that are formed from pressure and heat of the earth’s crust. An example is marble.
- mica* – Any of a group of minerals that crystalize in thin, somewhat flexible, layers.
- microorganism* – Any organism that is too small to be seen without the aid of a microscope.
- minerals* – An inorganic, solid homogeneous crystalline chemical element such as coal, salt, sulfur, etc.
- molybdenum* – This element is one of the most widely used heat-resistant metals. It is hard, silvery-white metal.
- organisms* – Any living thing.
- zeolites* – Any of the large group of hydrous silicates. Minerals of aluminum with alkali metals.
- perlite* – A volcanic glass with a shelly structure used in insulating, concrete, and plastic.
- pumice* – A light, spongy-looking rock formed when lava from a volcano hardens.
- pyroxene* – A group of minerals often found with other minerals called “feldspar.” This family consists of such minerals as iron, lime, magnesium, and silica.
- pyrite* – A compound of iron and sulfur commonly called “fool’s gold,” used in making sulfuric acid and in refrigerator fluid.
- sedimentary rock* – A type of rock formed from the breakdown of other rock.
- silicon* – The second most abundant element, making up 25 percent of the earth’s crust. It occurs mainly in combined form. Its symbol is “S.”
- strip mining* – A process of removing the overlying layers of earth to mine mineral deposits under the surface.
- technology* – The science of mechanical and industrial arts.
- tellurium* – A silvery-white semi-metallic element related to sulfur and selenium. It is used to improve the machining quality of metal products.
- thermodynamics* – The science that deals with the relationship of heat and mechanical energy and the conversion of one into the other.
- uranium* – A heavy radioactive element.

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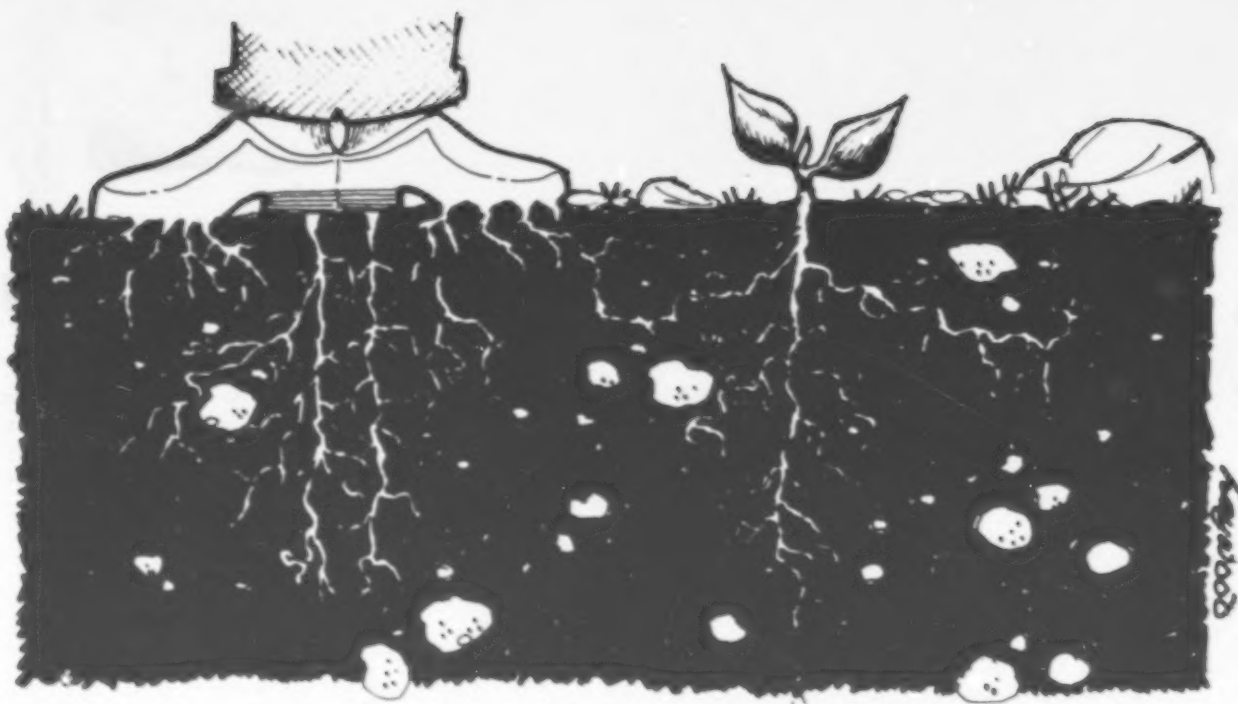
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SOIL

SOIL

Introduction:

Soil is perhaps the essential of our natural world; all life support systems are built upon it. With the addition of sunlight and water, soil produces plant life. Man uses both plants and animals that feed upon plants for food, fiber, medicine, dyes, leather, wool, and a thousand other things. Where soils are rich, man's life can be easy. Where soils are thin and poor, his existence can be harsh.

Early man was a gatherer of food and fiber. The supply was limited, scattered, and difficult to obtain. Day-to-day existence was hard.

As man developed, he learned to plant seeds in the soil and to care for the plants as they grew. He no longer needed to search for vegetable foods; he could produce his own. Where he had lived as a nomad, gathering foods in season, he now could settle in one place. He learned to irrigate, and the quantity and quality of his food supply increased. He soon had surpluses to trade with tribes who had not yet learned the farming skills. He domesticated animals. Communities grew into towns and towns became cities.

Here in Arizona's Salt River Valley, the Hohokam Indians built and operated major irrigation systems from before the time of Christ until about 1200 A.D. They had not yet domesticated large animals.

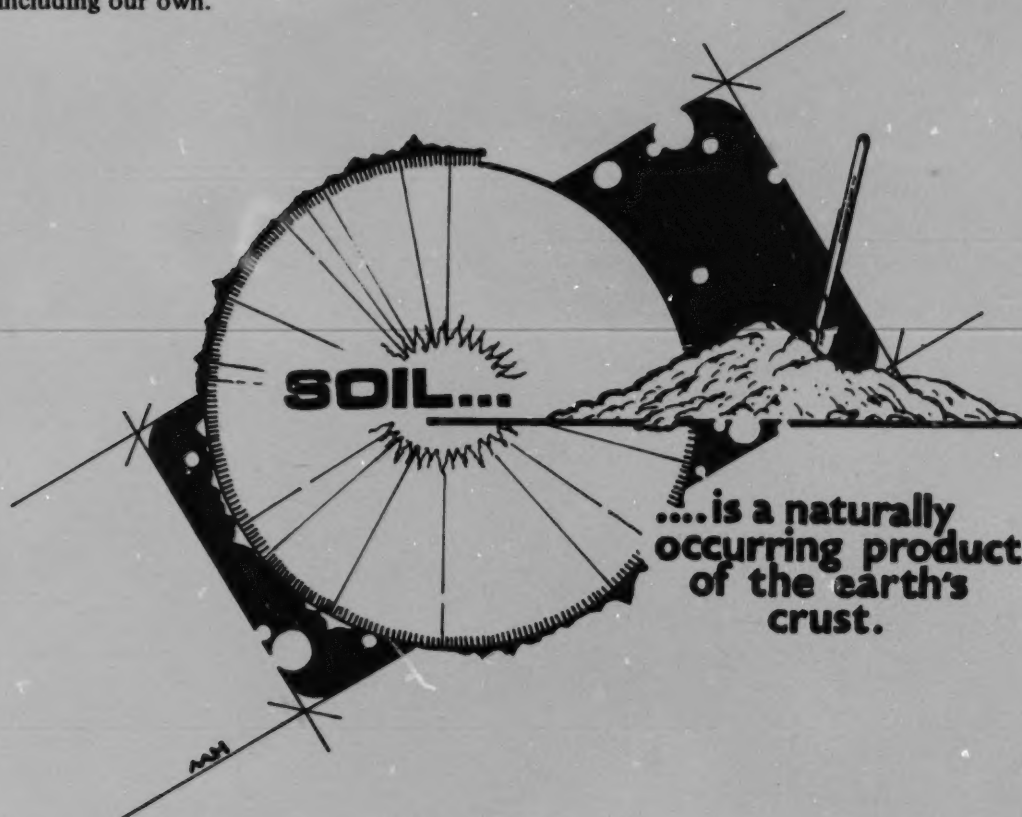
The Spanish, arriving not long after 1500 A.D., brought sheep, goats, horses, cattle, and pigs. The major thrust of western settlement, shortly after the Civil War, brought cattle as a primary enterprise. Farmers came to cultivate the valleys which could be irrigated.

Native vegetation that had grown on and protected the soil was rapidly depleted by increasing livestock numbers, and an accelerated erosion of the soils began. On desert lands, soil exposed to desert temperatures, winds, and short, violent rainstorms could sustain the regeneration of little plant life. Much topsoil was washed and blown away. The ability of Arizona lands to produce food and forage was severely reduced.

It was not until the 1920's and 1930's that we really became aware of the immenseness of our losses. Then came the efforts of the Soil Conservation Service, the Agricultural Extension programs, the Civilian Conservation Corps. Range Management and Forestry agencies, and schools to teach the importance of soils and the need for Conservation. The Dust Bowl disasters of the midwest gave graphic emphasis to our problems and conservation became a watchword. Every politician expressed concern for conservation—particularly for soil conservation.

The nation, and our State, began a slow turn-around in attitude and in use of agricultural lands. There began a long, slow recovery of the values that had been lost. We found that some of these losses would never be regained. This recovery is far from complete today—there is still much loss of topsoil due to overuse and misuse of our lands, but there has been substantial improvement. Today, perhaps the most important losses of valuable agricultural soils is in the development of human settlements—cities expanding into once-fertile fields, towns springing up in rich valleys, land having more value as homesites than as farms.

With today's world populations expanding, we can ill afford such losses of productive lands. Some of our soil loss problems have been slowed, but others have taken their place. We must re-remind ourselves of the role of the soil in our world—that it is the base for all life, including our own.



BASIC CONCEPT NO. 1 – Soil is a naturally occurring product of the earth's crust.

Suggested Activity – Science

Soil Composition – (out-of-doors):

Obtain a sample of soil, about one cup, place it in a quart jar, fill nearly full with water, place lid on tightly, turn upside down, and shake vigorously. Quickly turn this muddy mass and jar upright and set level. Note that a layer settles to the bottom in the first 20 seconds or so. Within several hours, another layer forms but the water is still cloudy. A third layer forms within 24 to 36 hours. Repeat with other soil samples.

The bottom layer is sand (large particles and visible); the middle layer contains silt (smaller particles); and the top layer is clay (very small particles, visible only with a

microscope). The material floating on the surface of the water is organic matter that has not decomposed.

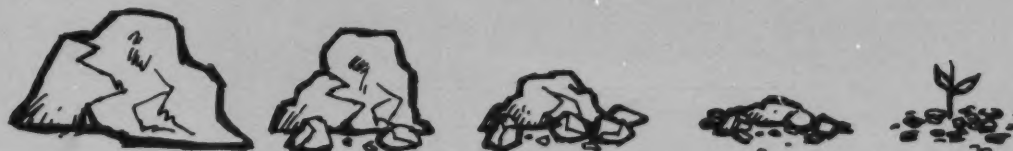
1. Soil is composed of sand, silt, clay, and organic matter—estimate percent.
2. These component parts vary in size.
3. Different soils contain different amounts of these component parts.
4. Muddy water in streams, during rainstorms and in floods, contains silt and clay.

Understandings:

A. Soil is formed by the breakdown of rock.

The erosional action of wind and water, together with mechanical and chemical weathering, breaks down rock to form soil.

Transportation and deposition of this material, over great spans of time, form soil deposits.



B. Parent material determines the kind of soil formed.

Soil forms from any kind of geologic material found on the surface of the earth. Soils formed from shales tend to be high in silt and clay, with a low resistance to water and wind erosion. Sandstones produce sandy soils, with lower water-holding capacity, but with greater resistance to erosion. Other geologic materials impart their characteristics to the soil being formed.

Soils generally contain one or more of eight elements—or combinations of these elements. Table I lists the most common elements found in the lithosphere. Elements are unevenly distributed throughout the earth.



TABLE I
Most Common Elements Occurring in the Lithosphere

Element	Percent
oxygen	47.3%
silicon	27.7
aluminum	7.8
iron	4.5
calcium	3.5
sodium	2.5
potassium	2.5
magnesium	2.2

C. Soil may consist of a variety of materials.

Soil components could include sand, silt, clay, organic matter, plant and animal life, and air. The organic matter provides food for plant and animal organisms.

These plant and animal components of the soil are mainly seldom-seen organisms—worms, grubs, bacteria, and molds—which decompose organic materials and prepare the soil for plant growth.

Soil must also contain air and water in order to support plant growth, and one-third of soil volume consists of air, water, and dissolved minerals which fill the spaces between particles of silt, clay, or sand.

BASIC CONCEPT NO. 2 – Soil is formed very slowly.

Suggested Activity – Science

From areas within the school yard, road cuts, and open soil banks nearby, identify differences in the above factors. Note that soils in the valley usually have more silt and clay—soils in flood plains may be sandy and soils of the mountains may be shallow. Draw pictures and write compositions on this subject.

Understandings:

A. Climatic factors affect the formation of soil.

Water, temperature, air, sunlight, and other climatic factors affect the formation of soil. Areas with low rainfall or low temperatures slow the soil-forming process. The reverse is true for high temperature and rainfall areas. In a warm, wet zone, vegetation is dense and the deterioration of organic matter is rapid. In cold or dry areas vegetation is more limited and decomposition very slow.

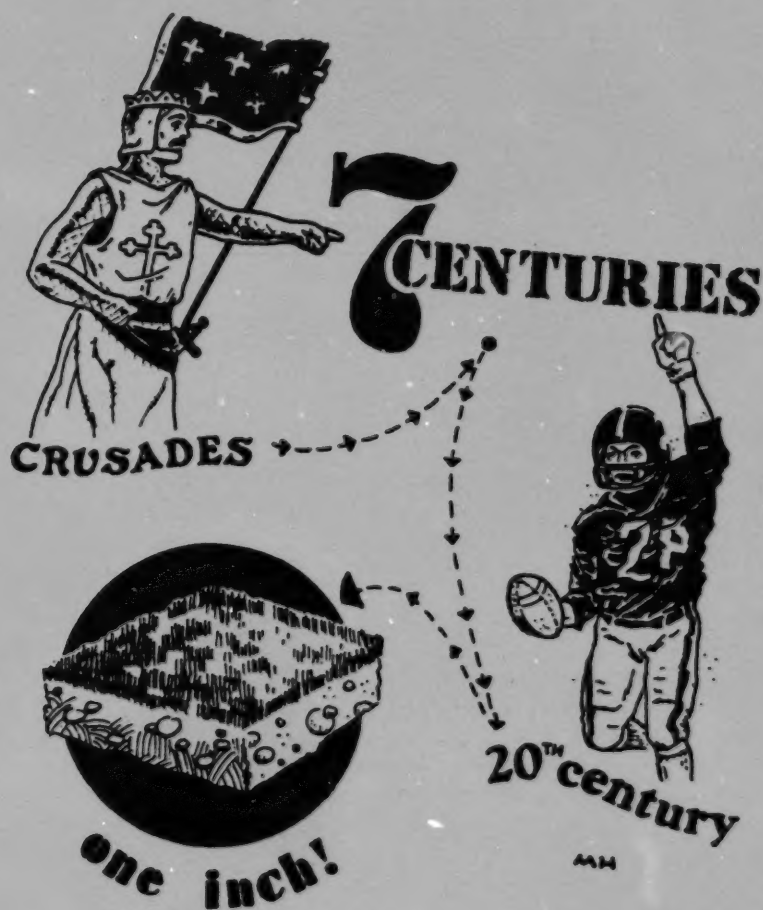
B. The transportation of soil material influences soil formation.

On steep slopes, soil particles are moved to lower elevation by wind, water, and gravity. The velocity of the wind, water, and particle size determines the distance soil is transported.

Deeper and finer soils usually result from water transportation which grinds, sorts, and deposits on level plains. Windblown materials are usually coarser and often form dunes, or pile against an outcropping of parent material.

C. Time affects soil formation.

The formation of soil is a cyclical process of constant erosion, transportation, and deposition followed by an up-lifting of land and a continuation of the process. The cycle of removing material from higher elevations and depositing it in lower elevations takes thousands of years. It has been said that it takes 700 years to form one inch of topsoil. Climatic factors and transportation processes can greatly modify this time—but consider the thousands of years necessary to form very deep soils.



BASIC CONCEPT NO. 3 – Soil is a renewable resource.

Suggested Activity – Science

School yard and area visible within range of daily activities to students.

Observe areas bare of vegetation or with sparse vegetation. Note movement of soil by the action of water or wind. *Recall dust in the air during windstorms and silt and clay in water—these are visible results of soil erosion.* The damage is twofold: (1) the soil is being displaced and can no longer support plants and animals as it did originally, and (2) pollution problems such as dust in the air cause health problems; excess soil in our water can cause loss of fish and animal habitat. However, removing silt from human water supplies is a very expensive operation.

DO:

Find an example of rill or gully soil erosion in the real world nearby or find pictures and examples in references. Draw pictures of it, write about it, and understand what is happening.

Understandings:

- A. Soil is a renewable resource – in the context of being continually replaced by deposition and by the recycling of materials from soil to parent material and back to soil.

Soil is also renewable by the revitalization of its depleted materials. The water, air, and dissolved minerals can be leached out of the soil, or extracted by plants. If there is a return of these nutrients by natural, or manmade processes, the soil can be said to be renewed.

- B. Geologic processes of wind and water erode, as well as build, soil.

Geologic erosion occurs under natural conditions. Soil, lacking adequate vegetative cover, suffers when exposed to wind and water. Soil is subject to four stages of erosion by water: rain splash, sheet erosion, rill erosion, gully erosion (see figures a, b, c, d).

During windstorms, soil is moved from where it has been, or may be used for plant life, to where it may become a problem. Arizona's dust storms are good examples of this. Different soil types are affected differently by both wind and water. Arid soils are more affected by wind than soils in temperate climates. Clay and loamy soils are affected less by wind than finer or more organic types of soil.

- C. Soil productivity can be maintained by using known agricultural, mechanical, and chemical processes. This maintenance is important to the welfare of people.

Agricultural practices such as crop rotation, contour plowing, mulching, and others, maintain and build soil. Allowing land to lie fallow after plowing permits air to mix with the soil. Adding gypsum to the soil may help solve problems relating to alkaline conditions—other mineral additions may help solve other problems.

In the United States, only about 20 percent of the land is suitable for cropland, and each year more land is taken out of production by the encroachment of cities, highways, and other human development. As national and world populations grow, these lands become more and more valuable as food production units. This also places greater production demand on each acre of remaining cropland.

BASIC CONCEPT NO. 4 – Soil is necessary to all living things.



A. Soil acts as one of nature's cleansing agents.

Soil functions as a natural filter, slowly removing contaminants and particles of suspended material from water. Most polluted water can be purified as it percolates through soil. Soil acts as a filter for suspended particles of clay or silt. Most human disease organisms carried by water are unable to live in soil. Soil is the medium in which organic materials decompose.

This is nature's way of cleansing the earth of waste materials from plants, animals, and man. The component parts of these decomposed materials become food for soil organisms and for the next generation of plants.

B. Soil is a regulator of water movement and use.

Water absorption, by soil, depends upon the subsoil, temperature, type, and amount of vegetation. The proper amount of water is essential to maximum plant growth. Excess water can occupy air spaces in the soil and decrease plant respiration.

Water is five times as heat-absorbing as soil. Soil, saturated with water, warms up slowly in the spring and cools slowly in the fall. These factors influence plant types and planting. Higher temperatures increase soil drainage by increasing plant absorption and transpiration.

Soil cohesion and adhesion factors hold water in the soil, resisting the absorption of water by plants.

- C. All living things, plant and animal, including man, are directly or indirectly dependent upon the soil for food and shelter.

The majority of man's food comes from plants, or animals that eat plants. Plant foods are stored in the soil. The soil contains the minerals, organic materials, air, etc. necessary for plant growth. Soil also serves as a depository for water and a base and anchor for plant root systems.

Man is an omnivore, who eats both plant and animal material. Herbivores eat plants and carnivores eat the plant eaters—so all depend directly or indirectly on plants for food. And plants depend upon the soil.

Animals depend upon burrows in the soil, dens in the parent rock material, and hiding places amongst the vegetation for cover. Man uses plant material to build shelter and plant and animal materials for clothing, which is essentially shelter.

soil IS NECESSARY TO ALL LIVING THINGS.



SUGGESTIONS AND ACTIVITIES

Language Arts

A. VALLEY ESSAY

Show the class a picture of a deep mountain valley. Have the students write an essay on what would cause the valley to change.
(Intermediate)

B. HEADSTONE CAPER STORY

Make an impression on drawing paper of an interesting headstone from a local cemetery. Write a story explaining (imaginary) the episode behind the inscription.
(Junior High)

C. LAND-USE HEARING

Have your class attend a public hearing or meeting concerning a land-use controversy; i.e., rezoning, land development, water use, etc. Have the students listen to what is said and watch the participants. How do people listen? Have them record (write down) questions and responses. Analyze participants as to their interest groups. How do their opinions differ? Evaluate the performance of the moderator. Is the moderator prepared? How well did he/she control the meeting? What could the moderator have done better?
(High School)

D. "DUST BOWL" READING

Have each student select a poem, short story, or novel about the "dust bowl." Determine how the writer used dialect. Have the class write an essay or short report on the use of dialect. In the analysis the student should consider the purpose and use of the dialect employed; i.e., development of setting, mood, or characters.
(High School)

E. SOIL NAMES

Have the class examine a soil map of Arizona. Explore the names of the soils. Are they named for people, places, or things? Are they descriptive? Consult your local Soil Conservation Service office or university about soil names and locations. Make up names for soils in your area based upon the characteristics and location of the soil.
(Junior High)

F. EDITORIAL ANALYSIS

Examine newspaper articles or editorials concerning farming or land use. What point of view does the author take? What is the intended audience? What is the purpose of the article? To inform? Entertain? Arouse emotion?
(High School)

G. WRITE A JOB DESCRIPTION

Write a job description for a soil technician. What qualifications should a person applying for the job have? What special skills should he or she have? Examine actual job descriptions for the proper format.
(Junior High)

H. FEEL THE SOIL

Place different types of soil in "feely boxes." Have the children describe what each soil feels like. Ask the children if they know where the different soils come from.
(Primary)

Social Studies

A. POLLUTION CLASS PROJECT

Separate the class into teams to research some pollution item and have the following questions answered:

1. Is it necessary to use pesticides or tolerate sediment?
2. Does erosion occur under natural conditions without man's influence?

Information — Most pollution problems relate to one or more of the natural resources. Choose:

- a. Soil pollution by accumulation of nitrogen from commercial fertilizer
- b. Pesticide accumulation in soil; accumulates in the soil and affects food chains
- c. Sewage disposal by septic tanks in soil
- d. Sediments from soil polluting water supplies, filling reservoirs and lakes, and deteriorating fish habitat

(Junior High, High School)

B. SOIL CAREERS

Study about careers related to soil. Some of these are: (a) soil conservation officers, (b) mining engineers, (c) soil chemists, (d) geologists, (e) city planners, etc.

(High School)

C. DISCUSS EROSION PROBLEMS

Discuss how erosion problems may be solved. What steps, procedures, and legal aspects need to be considered?

(High School)

D. SIMULATION GAME – LAND USE

The town of Cruz Bend lies in an area which has for years been the agricultural center of the state. The population of the city is 100,000 and is rapidly increasing. There is pressure to expand the city limits north to allow the city to grow. In the area of growth, much of the land is farmland; i.e., cotton, pecans, and pasture.

There is a demand by various segments of the community to rezone 1000 acres of this land for housing so as to provide for new residents and thus ease housing problems for the city. The Cruz river runs near the area and provides for the city's water supply and as a source of irrigation water. See the map of the area below.

You are members of the community and you are to attend a city council meeting to decide if the rezoning is to occur. First, decide what land uses could occur on the land. Develop various categories of uses and then break the class into groups with each group selecting one area of use. Have each group then develop a plan of action and a presentation to be made to the city council. Have the groups develop either maps, drawings, charts, or graphs supporting their proposal. Try to obtain group sizes of 5 to 7 (this would make about 5 or 6 groups for a 30-student class). Try to get an uneven number of groups; i.e., 5, 7, 9, etc. Once groups have been selected, have one student from each group be appointed to the city council. Have the council then get together and decide how it is going to operate the upcoming meeting. Have the council develop how it is going to evaluate each group's proposal. Then conduct the meeting, allowing each group 10 minutes to make their presentation. Allow for questions from the council and from the floor. Once completed, have the council go into recess and then reconvene and give its decision as well as its reasons for the decision.

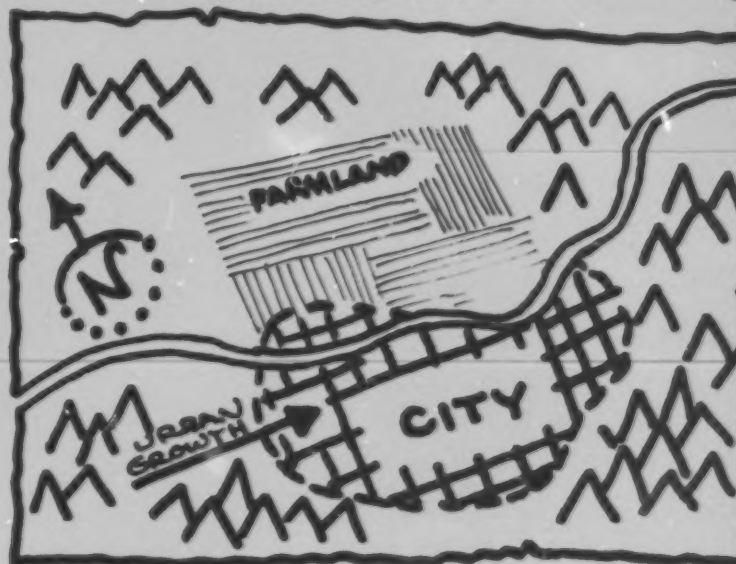
Geography – The city lies in a desert valley with mountains to the south, east, and west. The farmland is slightly sloping and lies at the foot of steep mountains which have a history of heavy rainfall during the summer months. There is little vegetation on any of the slopes. Water, while being supplied by the river, is being supplemented by wells. In the future, it is expected that most of the city's water will have to be pumped from underground. The soil is basically alluvial in origin.

Economy – Farming, while being the historical foundation of the city's economy, is becoming less of a factor today. Industries such as aircraft and electronics have become important, as is solar energy.

Society – The community seems to favor growth. There is a strong agricultural force in the city. There is a movement within the community for the preservation of the scenic beauty of the region and this group generally opposes the development of the area for homes or industry.

Discuss the following questions:

Is it easy to decide what to do?
What things do you wish you had to make a better case or decision?



(Junior High, High School)

E. BUILD A SOD HOME

Research the construction of sod homes built on the American prairie during pioneer times. After study, construct a model of one of these homes using a similar technique. List the advantages and disadvantages of these types of homes. (Junior High)

F. YOUR LAND

Find out how the land in your county has been used since it was settled by the white man. Compare this land use to the way the American Indians of the region used the land. Discuss the environmental impact of its cultural use. (High School)

Fine Arts

A. DESERT PAVEMENT

What image comes to your mind when the term "desert pavement" is mentioned? Create a picture of your interpretation of desert pavement. Where would you find such a material? How was it formed? How is it used? (Junior High)

B. TEXTURE COMPARISONS

Compare the texture of potters clay or some other commercial mix to various mixtures of soil (sand, silt, clay).
(Junior High)

C. CLAY ART ACTIVITY

Use clay to make figures. Try a series of stabs to form a figure. Make wind chimes of ceramic shapes. Pinch them into thin shells, open walls with cut-through design. When fired and glazed, hang them with wired weights inside to make a pleasing sound effect.
(Junior High)

D. DUST BOWL SONGS

American folksongs of the "dust bowl" era are rich sources of information on what happened to the grassland ecosystem when the dust storms came. A few musically inclined students might be asked to put together a report on the dust bowl. Have them use at least two separate media to present their findings. Most of the important songs, including the great Woody Guthrie ballads, are available on Folkways records, found in many school or public libraries.
(High School)

E. NATURAL SHAPE MOLDS

Create unusual forms by shaping clay around stones, sand bags, or other forms.
(Junior High)

F. PHOTOGRAPHIC TEXTURE STUDY

Take photographs of an area covered with soil or rocks. Take one photo at noon and one at either sunrise or sunset. How does the texture of the photo change? Identify the area that changed the most—that changed the least.
(Junior High)

G. RHYTHMIC PATTERNS COMPARED TO NATURE

Bring to class some articles or materials the surface design of which has a rhythmic pattern. This may be leather, metal, wood, glassware, textile, lace, or embroidery. Compare these to examples of rhythmic patterns in nature such as sand dunes, rocks, and soil.
(High School, Junior High)

H. NATURAL SCENES FOR PAINTERS

Nature and natural processes are a strong force in inspiring the young artist. A beautiful scene composed of the results of the workings of nature lingers in the human mind. The young artists who can visualize that a tree has about as much growth within the soil where it gets its minerals, water, and oxygen as it has above ground, and that

its health and beauty depend on natural functions, will have the opportunity to put more feeling and expression in their work.

In the school yard or on a field trip, choose an interesting tree or any kind of plant and, with the group, discuss the dependence of the plant on soil, water, air, and minerals; that the green colors are reflected from chlorophyll within the leaves which is also necessary for the plant to manufacture its food supply. Relate to others the wonders of nature that make a beautiful plant. Total scenes and specific parts of the processes, such as how a plant uses its roots to obtain minerals, water, and oxygen from the soil, should inspire various ideas in the participants' young minds. Ask for individual expressions in drawings as a result of the discussion.

(Junior High, High School)

I. MAKE A NATURAL COLLAGE

Make a design or picture with objects from the soil—sand, rocks, crystals, minerals, etc.

(Junior High, High School)

J. MAKE A POSTER

Make a poster with a slogan about man and his dependence on soil.

(Junior High)

K. NATURE OBSERVATION FOR ARTISTS

Encourage the students to observe vegetation in the immediate area. Note that there are various kinds—grasses, shrubs, medium and tall trees—and that each has different growth characteristics. Draw and compare. After observation and library reference study, discuss this natural process. Relate to a similar natural process in the soil. All soils are similar since they are basically made up of sand, silt, clay, organic matter, etc., but they are all different in that they contain different amounts of these component parts, and that different soil will support different kinds of vegetation. Further observe these differences in local soils in road banks, construction areas, dug holes, and in library references. Again, draw and compare. Add understanding of natural resources and natural processes to get more inspiration and feeling in the art assignment.

(High School)

L. MAKE A SAND SCULPTURE

Using dry sand, make a sculpture. Wet the sand. Make a second sculpture. Which sculpture was the best? Compare the reason with natural movement of dry sand.

(Junior High)

Mathematics

A. MEASURE THE ACRE

The standard unit of measurement for soil (land) is the acre. An acre contains 43,560 square feet and is an area slightly less than 209 feet square. Measure any area on the school grounds, such as a football field, and determine (a) the square feet and (b) the acreage.

Example: $300 \text{ feet by } 150 \text{ feet} = 45,000 \text{ square feet}$
 $45,000 \text{ square feet} \div 43,560 = 1.03 \text{ acres}$

The irrigation water applied to soil to grow food and fiber crops is measured in cubic feet per second (cfs) and in acre feet: 1 cfs of water flowing for 12 hours equals 1 acre foot.

1. If 3.5 acre feet of water is necessary to grow a vegetable crop during a growing season, how long would a $1/2$ cfs water stream have to flow onto one acre to fill the crop requirement for water? (Answer: $1/2 \text{ cfs} \times 6 [12 \text{ hour periods}] = 3.5 \text{ acre feet}$, time = 72 hours)
2. This water cannot be added at one time—it must be applied in seven separate irrigations. How many acre feet are added in each irrigation? Discuss. (Answer: $3.5 \div 7 = .5 \text{ acre feet per irrigation}$) (Junior High)

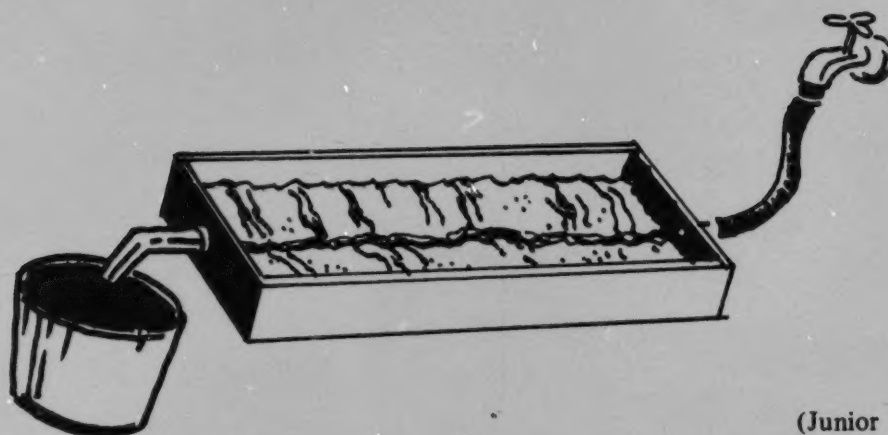
B. WATER AND SOIL

A cylinder containing 50 ml of soil is poured into 50 ml of water. The resulting mixture of soil and water occupies only 75 ml. Why doesn't it total 100 ml? How much pore space is present?

Pore volume = soil + pores + water-soil + water = $100 - 75 = 25 \text{ ml}$
(Junior High)

C. WATER VOLUME

Set up the following. Build a trough. Place a layer of moist sand to a depth of 2 to 3 cm. Use a piece of dowel or your finger to "cut" a channel down the center of the sand. Place a piece of plastic wrap over the entire setup. Incline the trough to a 10-degree angle. Turn on the water (slowly). Calculate the velocity of the stream by placing a small piece of cork in the channel. Repeat to obtain the stream's average velocity. Now, set the trough at a 4-degree angle and calculate the stream's velocity. What relationship do you see between the slope and the ability of the stream to move sand particles? Repeat the activity with angles of greater than 10 degrees and compare your results. Find a stream, or view pictures of streams. Do you see any similarities?



(Junior High)

D. SOIL AND FERTILIZER

Select five suitable containers. Label them as follows: None, $1/2$, 1, 2, and 4. Select a sandy, light-colored, low-fertility soil, or fine sand from a building supply company. Screen each sample to remove large particles and clumps. Obtain a small sample of commercial fertilizer (8 teaspoonfuls). The fertility should read 5-10-10, 5-20-20, 10-10-10, etc. Do not use a fertilizer with a "0"; i.e., 0-10-10. In the container marked "None," place 10 lettuce, radish, or beet seeds (bean seeds will do, but they take a while to use up their initial food supply). In the container marked " $1/2$ ", place $1/2$ teaspoon of fertilizer. Repeat with 1, 2, and 4 teaspoonfuls in the other containers. Mix the soil and fertilizer thoroughly. Plant 10 of the same type seeds in each container. Moisten the soil samples so that the water just starts to run out holes that have been punched in the bottom of each container. Continue to water the containers while keeping them in a well-lighted place in the classroom.

Once the plants start growing, keep a close record of their color and height. What is the effect of the fertilizer? Did the various quantities of fertilizer affect the plants differently? Did any seeds fail to germinate? Hypothesize why they didn't grow.

Finally, examine the fertilizer and determine what each of the numbers mean. If the bag or container it came from weighs 100 pounds, how much of each nutrient is present (in pounds)? If you had to spread 20 pounds of nitrogen on an acre of land and the fertilizer was a 10-10-10, how many bags would you have to buy?

(Junior High, High School)

E. SOIL LOSS EQUATION

Contact your local Soil Conservation Service office or write to the Soil Conservation Service office in Phoenix. Ask them for a copy of the *Universal Soil Loss Equation—Arizona*, Conservation Note No. 11. Find a soil in your area and utilize the equation to establish soil loss per acre for various return period storms. Compare different types of vegetation cover for the same area as well as various land management techniques. With the aid of local farmers and extension specialists, determine the loss in money if a 50-year storm occurs in your area. How long did it take to form that amount of soil—100 years, 300 years, 500 years, 1000 years?

(Junior High, High School)

F. GRAPH THE SOIL TYPE

SOIL TYPE (Arizona Irrigated Soils)	SURFACE AREA (Meter ² per Gram)	TEXTURE	
		Clay (percent)	Sand (percent)
Vinton Loamy Sand	24	6	83
Valencia Sandy Loam	33	7	62
Gila Loam	53	13	56
Laveen Loam	61	21	45
Glendale Loam	80	21	45
Grabe Silt Loam	121	24	16
Pima Silty Clay Loam	114	30	13
Vekol Clay Loam	115	34	37
Mohave Clay Loam	130	37	37
Cashion Clay	148	40	16

Graph the surface area per gram by the percent clay and sand. Which direction do the graphs go? How does the percent clay and sand relate to the surface area? Which particle has the greatest effect? Find an area equaling 148 square meters (Cashion Clay). Compare with the area of your classroom. What characteristics of soil does clay affect the most? How about sand? Finally, from the names of the soils, can you tell where they came from?
(Junior High, High School)

G. SOIL, WATER, AND TEMPERATURE

Heat and generation. Take two jars, cans, or beakers. Fill each with equal amounts of dry soil. Saturate one can. Place thermometers at equal depths. Place both cans in a sunny window. Take the temperature at intervals of 1 minute for 20 to 30 minutes. Plot the temperature changes for the time period. Repeat the experiment with different colored soils (light vs. dark). What effect does soil temperature have on plants and animals living in the soil? How about water availability and floods?

(Junior High)

H. CAN YOU?

An acre of soil 1 foot deep weighs about 4 million pounds. How many years would be required to lower the land by 1 foot if 330 pounds of material are dissolved and removed each year?

(Junior High)

I. PLANTS AND pH

Collect a sample of soil from each soil layer. Fill a test tube 1/3 full of soil and 2/3 full of distilled water. Stopper and shake. Allow the solution to settle. With pH paper, determine the pH of the soil. Repeat for a number of samples. Also, record the number and types of plants found where each sample was taken. Make a table of

Steps to solve:

1. Plug the computed gradient into Table 1 as shown. This will give the time of concentration—21 minutes.
2. Using this time and a 100-year return period storm, the rainfall intensity, i , is approximately 5.9 inches per hour.
3. To compute C , consult Table 2 and plug in the values for soil type and topography as shown.

$$C = \frac{140 \text{ acres} \times .60 \text{ (from Table 2)} + 80 \text{ acres} \times .30 \text{ (also from Table 2)}}{220 \text{ acres (total in the watershed)}}$$

$$C = .49$$

4. $Q = .49 \times 5.9 \times 220 = 636$ cubic feet per second

TABLE 1

Time of Concentration for Small Watersheds

Maximum Length of Flow (ft)	Type of Concentration (min)					
	Watershed Gradient (percent)					
	0.05	0.1	0.5	1.0	2.0	5.0
500	18	13	7	6	4	3
1,000	30	23	11	9	7	5
2,000	51	39	20	16	12	9
4,000	86	66	33	27	(21)	15
6,000	119	91	46	37	29	20
8,000	149	114	57	47	36	25
10,000	175	134	67	55	42	30
20,000	306	234	117	97	74	52

TABLE 2
Rational Runoff Coefficients

Topography and Vegetation	Values of C in $Q = CiA$		
	Soil Texture		
	Open Sandy Loam	Clay and Silt Loam	Tight Clay
<i>Woodland</i>			
Flat 0-5% slope	0.10	0.30	0.40
Rolling 5-10% slope	0.25	0.35	0.50
Hilly 10-80% slope	0.30	0.50	0.60
<i>Pasture</i>			
Flat	0.10	0.30	0.40
Rolling	0.16	0.36	0.55
Hilly	0.22	0.42	0.60
<i>Cultivated</i>			
Flat	0.30	0.50	0.60
Rolling	0.40	0.60	0.70
Hilly	0.52	0.72	0.82
<i>Urban Areas</i>	30% of area impervious	50% of area impervious	70% of area impervious
Flat	0.40	0.55	0.65
Rolling	0.50	0.65	0.80

Tables taken from *Elementary Soil and Water Meeting*, by Schwab, Barnes, Frevert and Edminster.

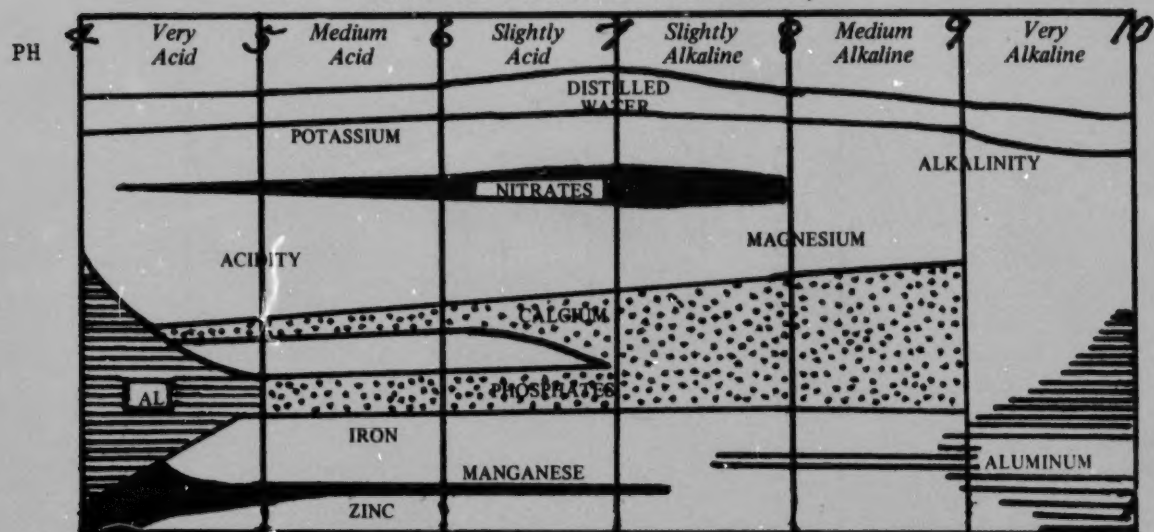
Activity — Obtain a topographic map which includes your city or town. Find a watershed on it. Have your class map it and determine what type of soil and vegetation it has. Compute the peak runoff for the watershed for a 50- or 25-year return period storm. Have them hypothesize what measures should be taken if people are to live near the stream channel fed by the watershed. Also, vary the land use for the watershed or imagine that cattle would be allowed to overgraze.

(High School)

plants and pH. Make sure to record how well the plants seem to be growing; i.e., do they look healthy? From the table below, determine what nutrients are likely to be present in the soil sample.

NUTRIENT AVAILABILITY CHART

Note: Width of Bar indicates relative availability



(High School)

J. COMPUTE PEAK RUNOFF USING THE RATIONAL METHOD

The formula is: Q (peak runoff in cubic feet per second) = C (runoff coefficient) $\times$ i (rainfall intensity in inches per hour) $\times$ A (area of the watershed in acres). Use Table 2 for finding C for various types of topography and soils. Use the following example to help explain the procedure.

On a topographic map you find a watershed of 220 acres, 140 acres of which is rolling cultivated clay loam and 80 acres of hilly sandy loam covered by woodland. On the map, it can be seen that the maximum elevation change for the watershed is 80 feet and the maximum distance of the watershed is 4000 feet. You must find out what the peak runoff for this watershed will be for a 100-year return period storm. Consult Table 1 for a view of the watershed.

Maximum elevation change is $1180 - 1100 = 80$ feet

Maximum length is line CDGA = 4000 feet

Watershed gradient = $\frac{80 \text{ feet (elevation)} \times 100\%}{4000 \text{ feet (length of watershed)}} = 2$

K. DETERMINE SOIL TEXTURE – LABORATORY METHOD

Collect two soil samples of the same soil (one sample of 110 grams and the second of 55 grams). Place the 55-gram sample in a pan, that has been carefully weighed, and put it in an oven to dry. Label the pan No. 1.

Place the 110-gram sample in a glass jar (with lid) and add 30 ml of saturated sodium oxalate solution plus enough water to make a "slurry." Stir by hand until all the soil is wet. Then, shake the mixture for 5 to 10 minutes or until all clumps of soil are broken apart.

Transfer the mixture to a 1000 ml graduated cylinder. Rinse all soil from the jar with distilled water and fill the cylinder to the 1000 ml mark. Stopper the cylinder and invert to mix the soil thoroughly.

Set the cylinder on a table and record the time. Based on Table 1 below, take a 25 ml sample after 1 minute from "X" cm with a pipette. "X" would equal the depth of the sample for a particular water temperature. For example, if the water is 25 degrees Celcius, the sample would be taken at 1 minute at a depth of 15 cm. In this sample, no particle would be sand; i.e., only silt and clay will be removed. Make sure you mark "X" cm on the pipette with a grease pencil. Place this sample in a small beaker and place in an oven to evaporate the water. Label this beaker No. 2.

For the clay sample, take a 25 ml sample from "Y" cm after 1 hour. "Y," in this case, would be found in Table 2 below. Again, if the water temperature is 25 degrees Celcius, the sample would be taken from a depth of 1.44 cm after an hour has elapsed. Make sure that "Y" cm are marked on the pipette. Place in a beaker as before and label No. 3.

TABLE 1

To Determine the Depth (X)¹
for Silt and Clay Sample

Water Temp. (degrees Celcius)	X (cm)
20	13.50
25	15.00
26	15.43
27	15.63
28	16.00
29	16.37
30	16.70
35	18.38

¹ Take sample after 1 minute.

TABLE 2

To Determine (Y)¹
for Clay Sample

Water Temp. (degrees Celcius)	Y (cm)
20	1.30
25	1.44
26	1.48
27	1.50
28	1.54
29	1.57
30	1.60
35	1.76

¹ Take sample after 1 hour.

If, for example, the three samples were as follows:

No. 1 – 49.1 grams (oven dry soil which was originally 55 grams)

No. 2 – 2.04 grams of silt and clay

No. 3 – 0.40 grams of clay

Based on the results in No. 1, the 110-gram sample would weigh (when dry)

$$110 \times \frac{49.1}{55} = 98.2 \text{ grams}$$

Calculate the percent of sand, silt, and clay in the soil.

Since the pipette samples contained 25 ml or 1/40th of the 1000 ml sample, each sample (No. 2 and No. 3) will have to be multiplied by 40 and then 1 gram should be subtracted from each total to take into account the weight of the sodium oxalate added to the initial samples.

Weight of No. 2 = $2.04 \times 40 - 1 = 80.6$ grams in the 1000 ml sample

Weight of No. 3 = $0.40 \times 40 - 1 = 15$ grams in the 1000 ml sample

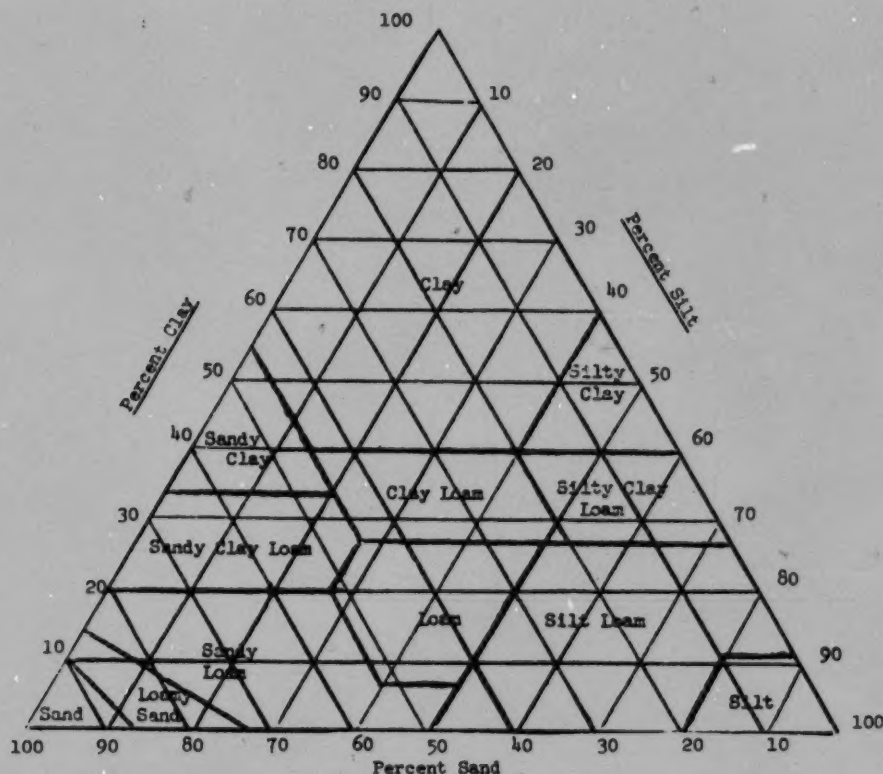
Percent of silt and clay (No. 2) = $80.6/98.2 = 82\%$ silt and clay

$$\text{Percent of clay (No. 3)} = 15/98.2 = 15\% \text{ clay}$$

Percent silt = $82\% - 15\% = 67\%$ silt

$$\text{Percent sand} = 100\% - 82\% = 18\% \text{ sand}$$

Consult the following soil triangle to determine the texture of the soil used in this example. In this case, the soil would be a silt loam. Follow the procedure above for various soils found in your area.



(High School)

Science

A. SOIL FORMATION

Use a bimetal bar (copper and iron or brass and copper) to examine the effects of temperature on two different substances. Heat the bar after measuring each metal's length. What happens? Freeze the bar. Place the bar in some water and freeze. Once it is solid, chip away half of the ice. Heat the exposed end with a candle or Bunsen burner. Again, what happens? How does it compare with rocks exposed to freezing and heating? Eventually, what happens to rocks which are subjected to various temperature extremes?

(Intermediate)

B. PREPARE THE SOIL

Prepare two cans of rich soil. Place one can in an oven and bake it for about 30 minutes. This should kill the microorganisms within the soil. Plant 5 lettuce, radish, or beet seeds in each soil. Observe and hypothesize the success of the plants. This activity shows that soil is truly a living community of organisms and inorganic material working together.

(Intermediate)

C. OVERGRAZING

The effect of overgrazing, in terms of soil erosion, can be readily demonstrated on your school grounds. Find an area of soil on which people normally walk. You can usually identify these areas by the path left in the grass. Sprinkle this area with a hose. Vary the spray from a fine mist to a strong jet to simulate a heavy downpour. Also, you might try to dig up this area (keep it intact) and grow some seeds in it. How does this soil compare to soil in adjacent areas which have not been walked on? Can overgrazed areas be reseeded easily? What does this activity tell you?

(Intermediate)

D. FIND AN ANIMAL HOLE, OR DIG ONE YOURSELF

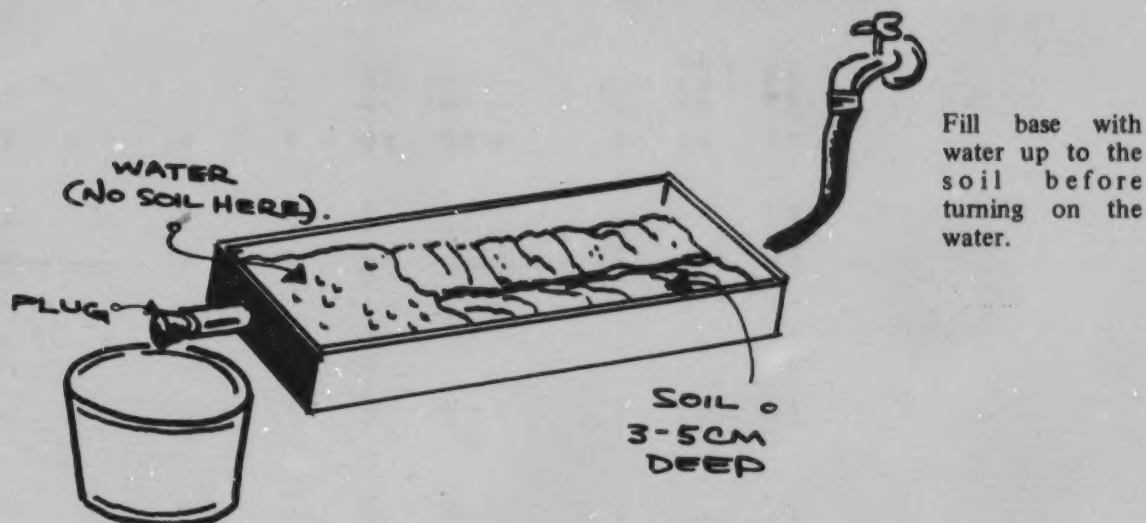
Place a small thermometer in the hole and also place a thermometer on the soil surface. Be sure to shade the thermometer on the surface. Record the temperature differences at various depths (2 inches, 6 inches, 1 foot). What effect does soil have on the temperatures beneath the soil surface? What implications does your finding have on wildlife? On man?

(Junior High)

E. SOIL EROSION

Make this device. Plug up the drain hole to create a small lake at the lower end of the trough. What forms in the pool of water? Describe it and make a sketch of its shape and how it changes over time. Where does the material come from? How is it transported? Now, pull out the stopper. What happens to the soil? With the stopper open and the water running, raise the trough. How does the velocity change? How does the movement of soil change? Does the size of the particles moved change? What would happen if the hole was again plugged and the water continued to flow? Again,

find photographs of the conditions shown in this activity. Draw pictures of the activity seen in the trough. On a small scale as well as large, what characteristics do areas such as the one forming in the water have? Find such places as this on a world map. What activities of man seem to prevail in these places? (Agriculture)



(Junior High)

F. WATER INTAKE OF SOIL

Use a flat sponge. Pour water on it. Slope the sponge so that you can see any water that might run off. How fast does the sponge absorb water? Can sponge absorb water as fast as you can apply it? Continue until water runs out the bottom. Compare the sponge to Arizona soils. Can you imagine water hitting the soil as fast as this? When? What time of the year? Squeeze the sponge and repeat. What situation would this compare to? How does the "soil" compare to the dry "soil" used before?

Repeat the previous activity, but this time place a blotter on top of the sponge. What soil condition does this simulate? An example would be a tilled field or soil which has been trampled by cattle. Compare the soil to your school yard. Take a sample of soil which has been walked on. Pour water on it and note how fast water infiltrates. What implications does the blotter over the sponge have for land managers?

Repeat, but this time place the blotter on the bottom of the sponge. What conditions does this simulate? How could a condition like this originate in nature? What happens as you add water? How long does it take to saturate the sponge and get water to the bottom of the sponge? How could this situation effect runoff? What about plant growth? How could conditions like this be corrected?

(Junior High)

G. MAKE SOIL ARTIFICIALLY

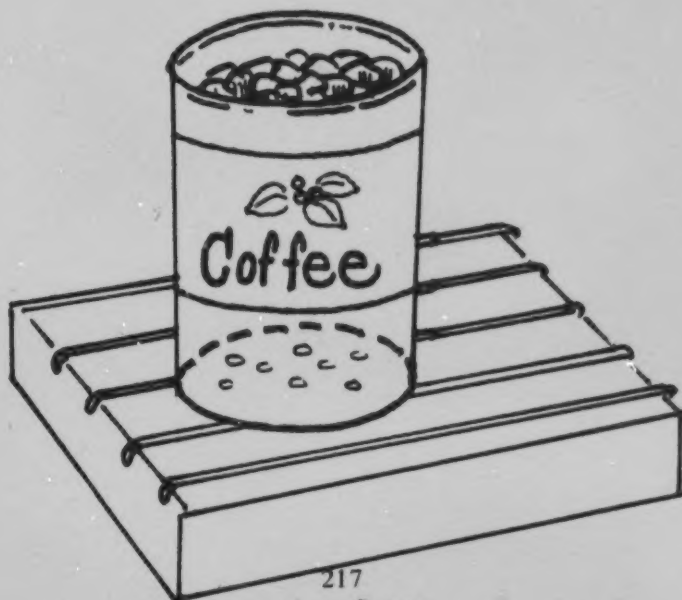
1. Make soil artificially with two pieces of sandstone, limestone, or even a concrete building block. Rub them together. How long does it take to produce a spoonful of fine particles? What natural phenomena does this simulate?
2. Fill a discarded jar with water. Seal the jar tightly. Put it in the freezer or leave it outside if the weather is cold enough. What happens?
3. Place a piece of limestone in a jar of vinegar. Watch the stone. Count the time it takes for bubbles to form. Heat the vinegar and record what happens. Where do we find acid (like vinegar) in nature? Try this same experiment with boiled distilled water. Then, with the aid of a straw, blow air through the water. What happens to the rock? Is the same thing happening? What is the source of the acid this time? Does this happen in nature? Find evidence to support your conclusion. HINT: Look for places which use limestone or similar materials which are then exposed to the weather.

(Junior High)

H. FIND A CLODDY SOIL

Find clods. Add a few drops of HCL on a clod. If it bubbles, use it for the activity. Place 1 kg of this soil into a 2-pound coffee can in which holes have been punched for drainage. Pour a quantity of water into the can and time how long it takes for water to run through. Again, pour water into the soil (now saturated) and time how long it takes for the water above the soil to sink in. Now, with another sample of soil, add a few spoonfuls of soda ash (sodium carbonate) to the soil and mix it into the upper 2 or 3 inches of soil. Pour water into the can as before. Are there any differences in the time it takes for water to run through? This activity can also be done with one soil sample where you pour water in the can and then pour sodium carbonate solution into the can. Are there any differences? Where could soda ash be used to seal the soil? How about stock ponds where the soil is high in calcium (which was indicated by the test with HCL).

(Junior High)



I. SOIL AND LIFE

Stake out a 1-foot square area on or near your school grounds. Dig down about 3 inches into the soil. Record any evidence of plants and animals you might observe. Repeat for different areas and compare your results. How does each type of matter found feel? Look? Smell? What is the importance of these materials? Record your observations in a table such as the one that follows.

Term and Definition	Description – How It Feels and Smells	Identifiable Parts of Plants and Animals
LITTER (Dead things on the surface)		
DUFF (Partially decayed matter)		
HUMUS (Almost completely decayed so that matter cannot be identified)		

(Junior High)

J. SOIL TYPES

Find a new road cut in which soil layers are present. Take a sample of each layer and grow plants in them. For this activity, bean seedlings do nicely. How do the soils differ in their ability to support plant life? If differences appear, which soil appears to be the least able to grow plants? What would you say should be done to correct the situation? Find evidence of what you have studied in your city or town. What other possible problems could this situation cause?

(Junior High)

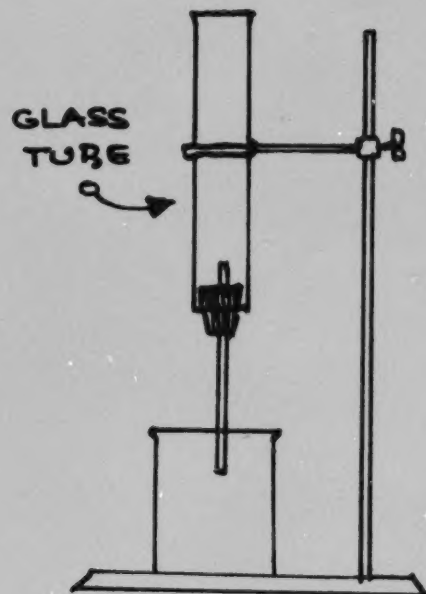
K. OBIS LITTER CRITTERS

Divide the class into groups of two or three. Find an area on or near your school grounds that has trees or bushes. Dig beneath these plants down to the soil. Remove the material (litter) and place it on a piece of white paper or in a white pan. Remove the dead plant parts and inspect each for living plants or animals. It might be helpful for each team to have a magnifying glass. Record the organisms by the number found of each type and the total number seen. As an art lesson, draw each different organism and then make up a name for it. The name should have some relevance to the animal or plant. As a companion activity, have some of the group find man-made litter and inspect these for organisms. Both of these investigations could be done under different conditions such as during the winter and summer, morning and afternoon, etc.

(Junior High)

L. CALCULATE PORE SPACE

Set up the apparatus as shown below. Fill the glass tube with marbles up to the 100 ml mark. Compute the average volume of the marbles using $V = 4/3 \pi r^3$. Count the number of marbles used. Calculate the total volume of the marbles used. Calculate the pore space in the cylinder. How much air space is available? How could this be measured? Could the marbles be rearranged to create more space? Redo the activity but this time use smaller marbles and then, b-b's. Is there a difference in pore space? What analogy can be made to soil and pore space? (Clay, silt, and sand)



(Junior High)

M. SOIL PERCOLATION

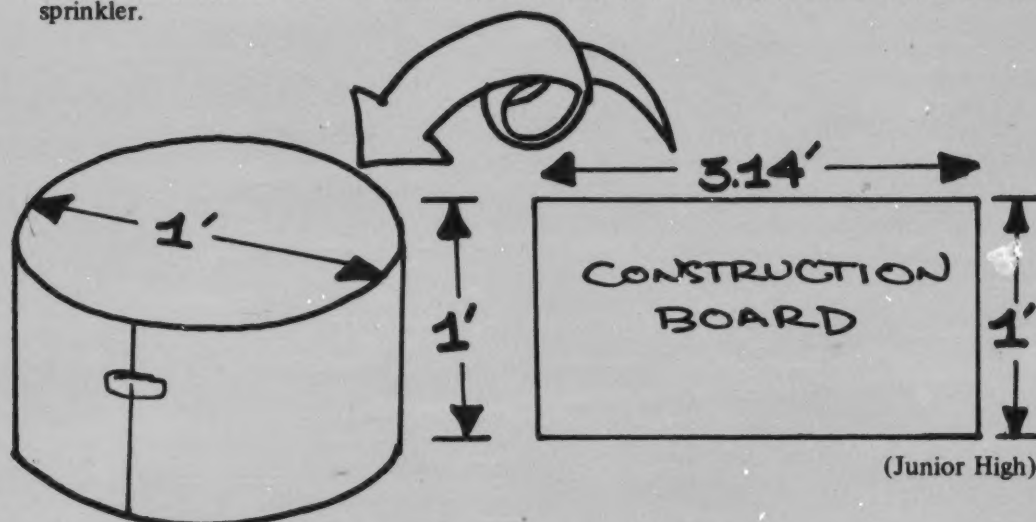
Obtain two glass funnels and place a small plug of cotton in their stems. Fill one funnel with a soil high in sodium ($2/3$ full). Now thoroughly mix 2 level teaspoonfuls of gypsum in about $1/2$ pint of sodium soil and place this soil in the second funnel. Place both funnels in a stand with a graduated cylinder under each. Fill both funnels with equal amounts of water. Over a period of several hours, compare water movement through the soil. Why are there differences? How could you test your conclusions? What would you need to know?

(Junior High)

N. SOIL PROTECTION

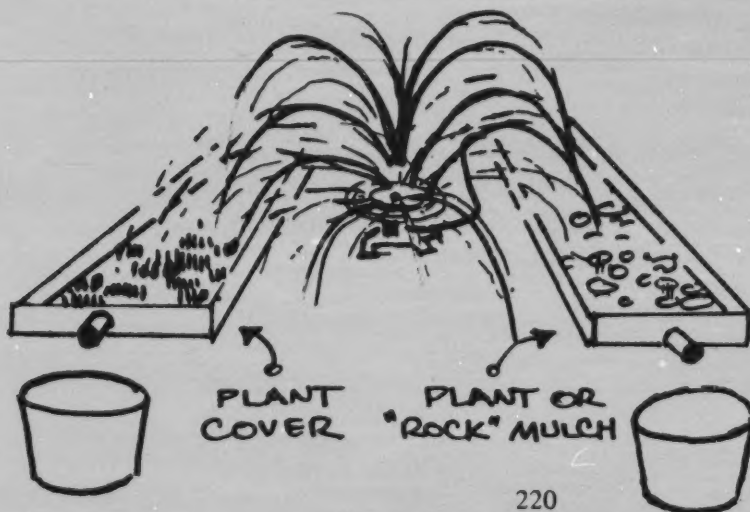
Plant some seeds (radish, wheat, grass, or bird seed) in the soil. Keep the soil wet and well lighted. How does the presence of plants affect the ability of the stream to move soil particles? Repeat, this time using a mulch or grass clippings on the soil. What is the effect of the clippings? Now try a "rock mulch." Again, what is the effect? Under what circumstances would you use these plants or rocks to protect the soil? What other effects do these coverings have on the soil? To make this activity more meaningful, weigh the soil in the container and determine the amount of soil removed.

Make sure to keep the volume of water applied constant. Other ideas include testing bare soil and various land management techniques (contour plowing, terracing, etc.). You could also time how long it takes for water to begin to run off. Instead of using a stream of water, set the box out in your school yard and apply water with a garden sprinkler.



O. SOIL COVER

Cut out four pieces of construction board or heavy paper so that they can be bent into a circle 1 foot in diameter. Cut the paper so that it is 1 foot wide. With a paper clip, join the loose ends so that a cylinder is formed. Place one cylinder on bare soil; one in an area covered with grass; one over a small shrub; and the final cylinder on an area covered with grass and bare soil. With a watering can, sprinkle equal amounts of water into each cylinder. Make sure that the can is held at a constant height. Once completed, unfold the cylinders (while damp) and lay them down, soiled side up, to dry. Once dry, apply some spray glue to the paper to preserve the soil on the paper. Label each "splash pattern" as to the soil covering used. What effect did the plant cover have on the amount of soil detached? In a heavy rainstorm, which area would you think should lose more soil? What implications does this activity have for farmers, landscape designers, or persons who work with the soil? Aside from detaching soil, what other effects does rain striking the soil have?



(Junior High)

P. EXAMINE THE PLANT

Obtain a bean or pea plant. Wash the soil from the plant's roots. Observe the bumps or nodules on the roots of these plants. Remove a nodule and make a cross-section microscope slide. What is contained in these nodules? How do they help the plant?

(Junior High)

Q. SPLIT THE ROCK

Find a porous rock. Soak it in water overnight. Freeze it in a refrigerator. Does anything appear to be happening to the rock? Prior to the activity, weigh the rock. After it has been soaked, reweigh. After the rock is removed from the freezer weigh all fragments as well as the rock. How much of the rock was broken apart?

(Junior High)

R. EROSION

Pack grass seed into a small jar or bottle. Seal the bottle tight. Moisten the seeds with 10 to 20 drops of water prior to sealing. Place the jar in a warm spot for a few days. What happens to the jar? How does this compare to nature? Find examples of this around your school grounds. What effect do the plants have on the ability of water, temperature, or chemicals to wear down rocks? Do each of these factors work by *themselves* or do they work in combination?

(Junior High)

S. THE EGYPTIANS

Review literature on how the Egyptians cut the stones for their pyramids. What property of water and plants did they take advantage of? See if you can obtain a brick (red) which has holes in it. Also obtain a piece of doweling which fits tightly into the holes in the brick. Pour water on the wood and onto the holes. Keep the wood wet. What happens to the brick? Is this similar to what happened to the jar and seed activity above?

(Junior High)

T. SOIL TEMPERATURE AND GROWTH

Examine soil for temperature and plant growth; also inferences about soil bacteria, fungi, and nutrient availability.

Soil Temperature	Conditions During the Growing Season
Less than 40° F	No growth, soil bacteria and fungi not active
40° F to 65° F	Some growth, some bacteria and fungi, moderate activity
65° F to 70° F	Fastest growth, best conditions for bacteria and fungi
70° F to 85° F	Some growth, some bacteria and fungi, moderate activity
Greater than 85° F	No growth, soil bacteria and fungi not active

(High School)

U. VEGETATION AS AN INDICATOR OF SOIL pH

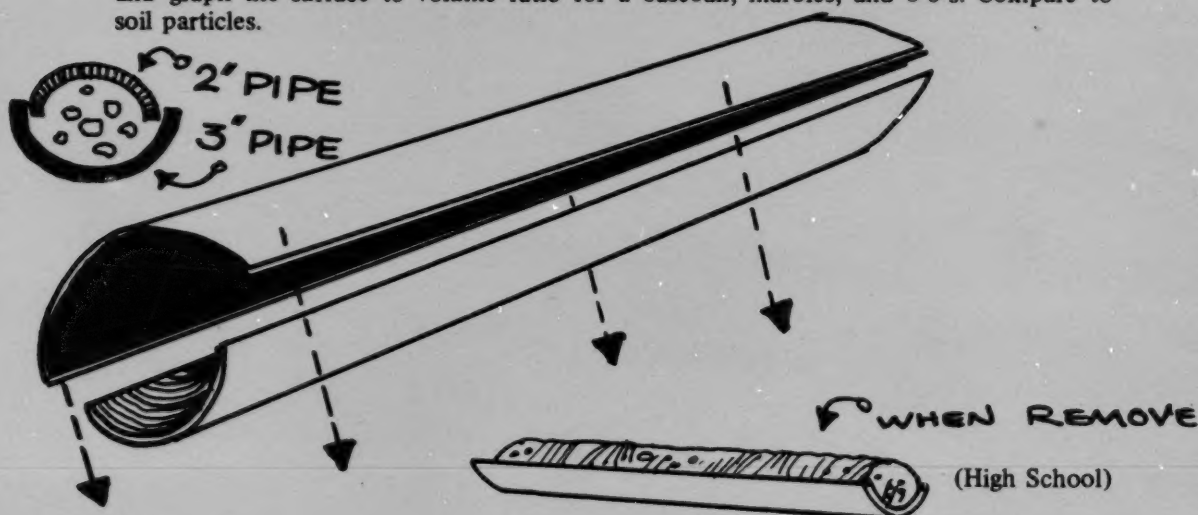
pH	Vegetation
4.0-5.0	Rhododendron, camellia, azalea, blueberry, fern, spruce
5.0-6.0	Pine, fir, holly, daphne, oak, birch, willow, rhododendron, spruce
6.0-7.0	Maple, mountain ash, pansy, aster, peach, carrot, pine, fir
7.0-8.0	Beech, mock orange, asparagus, sagebrush

While not many plants are represented here, there is enough to make an examination of soil pH and plants. Compare plants in your area to the pH of the soil. Use a pH test kit and do a visual inspection of the plants in the area. Make a table like the one above for your city, town, or school. Add these plants to the list above.

(High School)

V. SOIL PARTICLE

If a microscope is available, examine sand, silt, and clay particles. Also, examine "micro-monolith" specimens. Discuss the surface to volume relationship of each type of particle. Using the formula for the surface area of a sphere and for volume, compare and graph the surface to volume ratio for a baseball, marbles, and b-b's. Compare to soil particles.



(High School)

W. WATER-HOLDING CAPACITY OF SOIL

Divide the class into groups of two. Have each group observe a different patch of soil. Compare each soil for color, texture, organic matter, etc. After recording their observations, have each team collect a soil sample. Use plastic bags or a paper sack. Place the soil on a piece of paper (keeping each sample separate) to dry. Once dry (this can be speeded up by placing the soil in an oven), give each team an orange juice can and some filter paper. With a rubber band, cover the bottom of the can with the paper (see below). Weigh the can and record its weight. Fill the can about 1/2 full

with soil. Reweigh and record the weight. Fill a large pan with water and immerse all cans so that the soil is saturated. Let the cans remain in the water overnight. The next day, remove the cans and let them drain for 1/2 hour. Once drained, dry the outside of the cans and reweigh. Record the can's (with soil and paper) weight.

Weight of dry soil = weight of soil + can + paper - weight of can + paper
 Gain in weight due to immersion = weight of can + soil + water - weight of can + soil

Percent moisture-holding capacity = $\frac{\text{Gain in weight due to immersion}}{\text{Weight of dry soil}} \times 100$

Have each team place its findings (moisture-holding percentage) on the board using a table such as the one shown below. Did the teams with similar soils get similar results? Did any soil hold more than its own weight in water? How is water-holding capacity related to vegetation? Compare your results with the vegetation on the study site. How can vegetation affect the soil's water-holding capacity? Collect samples from around your town and test using this procedure.

Soil Color*	Teams												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Dark	60		62			56							66
Medium		5		7			5			8		6	
Light					18			25	20		19		

*Other soil characteristics can be substituted for color.

Figures within the table are each team's findings for moisture-holding percentage.
 (High School)

X. RAINFALL AND PLANT GROWTH

	Dormant Season	Growing Season
Form of Precipitation	Snow or Rain	Rain
Rate of Precipitation	Low	High
Duration of Rainfall	Long	Short
Drop Size	Small	Large
Area of Storm Rainfall	Large	Small

Compare this chart to Arizona rainfall patterns. When is the dormant season? When is the growing season? How would each season's storm affect the soil? When would local floods seem to be most likely? How about downstream floods? Give some examples of upstream and downstream floods. When would each occur? (High School)

VOCABULARY

- clay* – Mineral soil particles less than .002mm in diameter.
- climate* – A combination of natural conditions including air, temperature, water (precipitation), and other factors.
- compost* – A mass of decomposed organic matter made from waste plant residues.
- conservation* – Saving by wise use of planned management, etc.
- domestic animal* – An animal, tamed and kept by man to provide meat or milk, or serve as beasts of burden, or as pets.
- erosion* – The wearing away of land by wind and water.
- geologic time* – Long periods of time, thousands and millions of years, in which natural changes occur on this earth (includes the soil-forming process).
- legumes* – Pod-bearing plants that have nodules (knots) on their roots, each containing bacteria with the power of taking nitrogen from the air. Legumes are high in protein and excellent soil builders.
- organic matter decomposition* – Organic matter breaks down in the soil by the action of bacteria and other soil organisms. The component parts of decomposition are plant food for the next growth of plants.
- organic matter* – Decomposed plant and animal matter returned to the soil. It is food for animal organisms, provides fertility for future plant growth.
- plant food* – Substances that plants must have to live and grow—major elements are nitrogen, phosphorus, and potash; minor elements are copper, lead, zinc, molybdenum, and boron.
- silt* – Smaller particles of rock that you cannot see with a microscope (0.002mm to 0.05mm)—it feels smooth and velvety.
- soil* – That upper layer of earth made up of sand, silt, and clay mixed with decomposed plant and animal matter, constituting that part of the earth's surface in which plants grow.
- soil cleansing action* – Soil filters and purifies water.
- soil organism* – A small animal that lives in the soil.
- soil parent material* – Geologic material from which soil forms.
- soil texture* – Term indicating coarseness or fineness of soil mass.
- subsoil* – Soil in the natural process of becoming topsoil—it contains some water, minerals, and air to help support plant growth. That layer of earth just under the topsoil.

tillage — The operation of implements through the soil to prepare seedbeds and rootbeds.

topsoil — The surface layer of soil that contains higher level of fertility and is most important in plant growth.

virgin soil — A soil that has not been significantly disturbed from its natural state.

water-holding capacity — The ability of soil to hold water—sandy soils usually low; clay soils are high. Water-holding capacity of soil may be improved by use of organic matter.

BIBLIOGRAPHY

The following list of resource materials and sources is just a beginning but it should help you get started with your study of soil. No effort has been made to recommend any one particular resource over any other; whether listed or otherwise.

NOTE: Please check the wildlife, plant, and other sections for additional ideas and sources of materials.

1. Contact your county agricultural agent for the excellent materials produced by the Arizona Cooperative Extension Service.
2. Contact your local high school or community college agricultural departments for resource materials.

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WATER

WATER

Introduction:

Water covers approximately 71 percent of the earth's surface. In spite of its abundance, however, we can hardly afford to take this marvelous substance for granted.

Water, taking advantage of its abilities to change form from solid to liquid to vapor, shapes the surface of the earth by wearing down mountains and filling valleys; it creates lakes and builds flood plains; it is absolutely essential in the creation and functioning of all living cells; it moderates climate by moving heat from hot parts of the earth to cold spots; and is part of endless other functions.

Water is both the friend of man and can be man's enemy if he does not consider its force. It is a universal solvent, has an active part in nearly every natural process, is rarely chemically pure, and is one of the most interesting chemical substances studied by man.

Water plays a vital part in the life process of all living things. It helps to shape our physical environment and to regulate our climate. Its quality and distribution determine, to a great extent, our population patterns, the nature of our economy, our sources of power, modes of transportation, and even our individual life styles.

The politics of water have varied from western range wars, to problems with irrigation rights, to the modern Central Arizona Project controversy, to the water problems of the City of Tucson and Pima County mines.

A natural body of water, depending upon its mood, may contribute to our physical well-being and aesthetic enjoyment, or it may cause widespread destruction and death.

It is of the utmost importance that we learn as much as possible about this remarkable chemical compound, so that we may use it wisely for our own benefit and assure future generations of the same opportunity.

BASIC CONCEPT NO. 1 – Water is a chemical compound, H_2O , with unique chemical and physical properties.

Water (H_2O) is the only substance that exists simultaneously and abundantly as a solid (ice), liquid (water), and gas (water vapor) over large areas of the earth's surface.

The water molecule consists of two hydrogen atoms bonded to one oxygen atom at an angle of 105 degrees (see Figure 1). This peculiar configuration results in an uneven distribution of positive (protons) and negative (electrons) electric charges in the molecule. The "polar" nature of the molecule, in turn, helps to explain some of water's unusual properties.

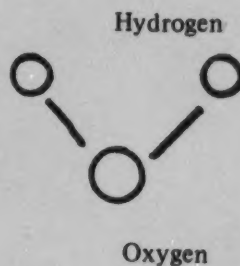


Figure 1. Water Molecule

Understandings:

A. Water, the "Universal Solvent."

Water is often called "the universal solvent" because it has the ability to dissolve so many other substances. It is, therefore, the medium in which most of nature's chemical reactions occur.

B. Water can store and absorb heat.

Its remarkably high specific heat (one calorie of heat is required to raise the temperature of one gram of water by one degree Celcius) gives water the ability to absorb and store great quantities of heat energy without undergoing very drastic temperature changes.

C. The characteristics of water depend on its physical state.

Water changes to a solid at 0°C ("freezing point") and to a gas at 100°C ("boiling point"), and these changes in state involve relatively great transfers of heat energy. It is an odorless, tasteless, slightly compressible liquid which appears bluish in thick layers. In its gaseous state (water vapor) it is invisible (clouds, fog, steam, etc., are composed of liquid water droplets which are large enough to be visible).

D. Water volume changes with temperature.

Most substances continue to contract as they cool, but water does so only until its temperature reaches 4°C . At that point, it reaches its greatest density and, if cooled further, will begin to expand again as it turns into ice.

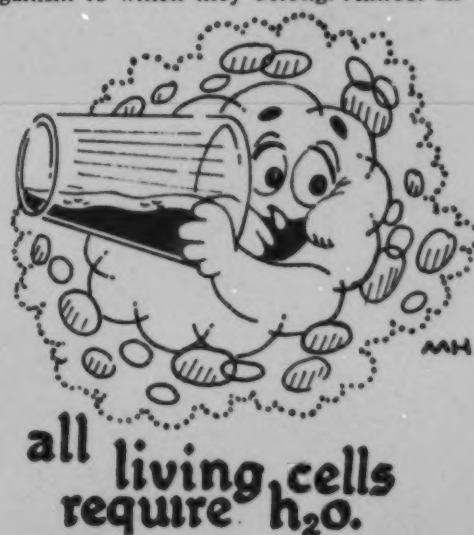
BASIC CONCEPT NO. 2 – Water is necessary for the life processes of all living things.

All forms of plant and animal life must have water in order to survive. The protoplasm of which living cells are made is mostly water, and water plays a vital role in all of the basic life processes. Water carries nutrients to, into, and throughout living cells, and carries waste materials out of the cells and organism to which they belong. Almost all of the myriad chemical reactions in living things take place in a water medium (photosynthesis is an example of this). Many kinds of animals and plants can survive only in a water environment.

Understandings:

A. Living cells are dependent upon water to maintain the life processes.

Each living cell is a beehive of chemical activity. The cytoplasm in which the parts of the cell are suspended, and through which all of the various chemical reactants and products circulate, is made up mostly of

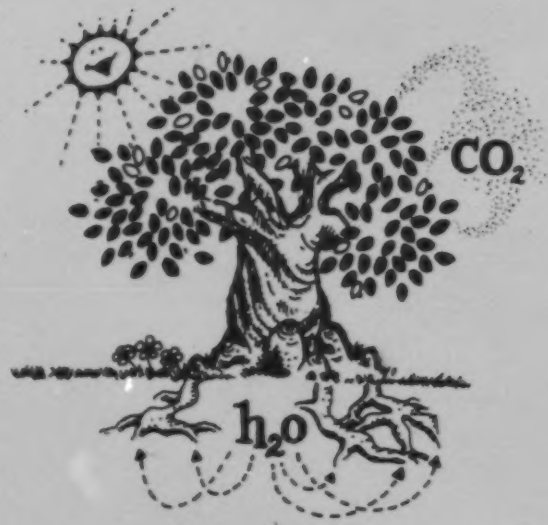


water. Water, the major component of animal "blood" and plant "sap," transports nutrients to the cells, and carries away various waste products.

B. Water is essential to the process of photosynthesis.

Photosynthesis is a process, carried on only by green plants and some protozoans, which is essential to the existence of all life on earth. Plants take water (H_2O) from the soil and carbon dioxide (CO_2) from the air, and, using the energy from sunlight, rearrange their molecules to form carbohydrates (starches and sugars).

Ultimately, all living things depend upon these carbohydrates for the energy to carry on their life processes.



C. Water provides the essential habitat for many animals and plants.

All fish, many invertebrates, some species of reptiles (turtles, sea snakes), and marine mammals (whales, sea cows) have adapted completely to an aquatic environment, and perish if removed from the water.

Amphibians (frogs, toads, and salamanders) must spend part of their life cycle in the water, breathing by means of gills in the larval stage, and returning to the water to breed as adults. Other animals (waterfowl, beavers, otters, etc.) fill important niches in aquatic or marine ecosystems, and quickly disappear from areas that dry up or become polluted.

Algae are photosynthetic plants that absorb nutrients directly through their body walls rather than through a root system. Therefore, they can live only in water or in an extremely moist environment.



D. Water helps living things to regulate their temperature.

In order to change from a liquid to a gas, water must absorb relatively large amounts of heat (540 calories per gram). Therefore, the evaporation of water from the skin of animals or plants draws heat from the body and maintains a stable body temperature. The impact of such evaporation can have a dramatic effect on local climate (drive through an orange grove in summer).

BASIC CONCEPT NO. 3 – Water serves man in many ways.

Virtually all of man's basic activities require the use of water. It is used in the growing, processing, and preparation of our food; in the production of most of our manufactured goods; in the cleansing of ourselves, our dishes, our cars, and our homes; in the disposal of waste materials; in the transportation of both people and products; in the production of electric power; and in many of our most pleasurable leisure-time activities.

Understandings:

A. Man is increasing his use of water.

The per capita home use of water (for such things as drinking, bathing, cooking, laundering, toilet flushing, car washing, and lawn watering) in the average American community is about 50 gallons per day. Agriculture and manufacturing use tremendous quantities of water, and our coastal and inland waters are sources of recreation for rapidly increasing numbers of people (see Table 1 and Table 2).

TABLE 1

**Estimated Municipal, Rural Domestic, and Industrial Water Requirements
in Acre-Feet in 2020**

[From 1965 Cooperative Inventory Report, U. S. Bureau of Reclamation]

Hydrologic Study Area	Municipal	Rural Domestic	Industrial (private)	Total
Little Colorado River	30,100	2,700	17,000	49.00
Upper Colorado River	4,900	900	1,000	6.00
Lower Colorado River:				
Lees Ferry to Parker Dam	2,700	300	5,000	8.00
Parker Dam to International Boundary	43,100	1,100	400	44.00
Bill Williams River	300	100	3,000	3.00
Central Arizona area	1,711,000	6,300	20,000	1,737.00
Upper Rivers area	17,300	1,700	13,000	32.00
Upper Gila River	5,100	900	35,100	41.00
Lower Gila River	3,700	200	13,000	16.00
Sulphur Springs	7,500	1,100	10,000	18.00
San Pedro River	16,000	1,000	30,000	47.00
Santa Cruz River	483,800	1,700	20,000	505.00
Mexican Drainage	0	100	0	.10
TOTAL	2,325,500	18,100	167,500	2,511.10

TABLE 2

World's Estimated Water Supply

Location	Surface Area (square miles)	Water Volume (cubic miles)*	Percentage of Total Water
SURFACE WATER			
Fresh-water lakes	330,000	30,000	.009
Saline lakes and inland seas	270,000	25,000	.008
Average in stream channels	—	300	.0001
SUBSURFACE WATER			
Vadose water (includes soil moisture)		16,000	.005
Ground water within depth of half a mile	50,000,000	1,000,000	.31
Ground water— deep lying		1,000,000	.31
OTHER WATER LOCATIONS			
Icecaps and glaciers	6,900,000	7,000,000	2.15
Atmosphere (at sea level)	197,000,000	3,100	.001
World ocean	139,500,000	317,000,000	97.2
TOTALS (rounded)		326,000,000	100

*A cubic mile of water equals 1.1 trillion gallons.

B. Water transportation is important for world commerce.

Water transportation is still one of the cheapest means of carrying large quantities of goods from one place to another. The oceans and navigable inland waterways, such as the Great Lakes and the Mississippi River system, provide economical transportation for raw materials and finished products upon which we all depend. This, in turn, helps keep prices down for the consumer.

C. Water power produces some of our electricity.

Much of the electrical energy used by man is generated by the power of moving water. Dams and hydroelectric generating plants have been constructed on most of the world's large rivers, and some countries (such as the Netherlands and France) are even harnessing the tides to provide electric power. Glen Canyon Dam, Hoover Dam, and Roosevelt Dam are examples of hydroelectric projects here in Arizona.

D. Water is an important recreational commodity.

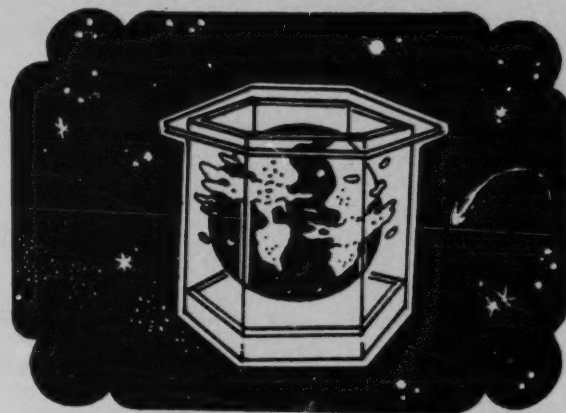
Water serves man's increased leisure time as a source of recreational activities. Fishing, swimming, boating, and water skiing are growing dramatically in popularity, and numerous artificial lakes have been created and stocked to cater to these activities in Arizona. Most importantly, perhaps, the natural beauty of lakes and streams (and of the wildlife associated with them) has a relaxing and restorative effect on man's soul in these hurried and harrowing times.

BASIC CONCEPT NO. 4 – Water is a renewable natural resource.

Understandings:

A. The total amount of water on earth is more or less constant.

The earth and its atmosphere contain about 940 million cubic kilometers of water. Although the water exists in three states (ice, water, and water vapor), the relative amounts of which are varying constantly, the total quantity remains virtually unchanged. Most of the water, more than 97 percent, is in the oceans; about 2 percent is tied up in glaciers and ice caps; about 0.6 percent is in the ground; and about 0.3 percent is in the atmosphere. Thus, less than 0.1 percent of all the earth's water is on the land surface (in streams, rivers, and lakes) at any given time.



'terrarium' in space.

OUR TERRARIUM (EARTH) WATER SUPPLY
IS CONSTANT, DYNAMIC AND MAY BE
RENEWED MANY TIMES.

B. The earth's water system is dynamic.

Water is always on the move, changing form in a cyclic pattern, driven by energy from the sun, and responding to the gravitational forces of the earth, moon, and sun.

The hydrologic cycle, or water cycle, can be described in its most basic form as the sequence in which water from the oceans evaporates into the atmosphere, precipitates from the atmosphere as rain or snow, and eventually returns to the sea through the drainage system of streams and rivers (see Figure 2).

The complete hydrologic cycle, however, is somewhat more complex. The atmosphere gains water vapor by evaporation from numerous sources, such as lakes, streams, and moist ground as well as from the ocean. Water vapor is also gained by transpiration from vegetation (and to a much lesser degree from animals) while some water percolates into the rock layers of the earth's crust, where it is trapped until pumped out by man and returned to the cycle.

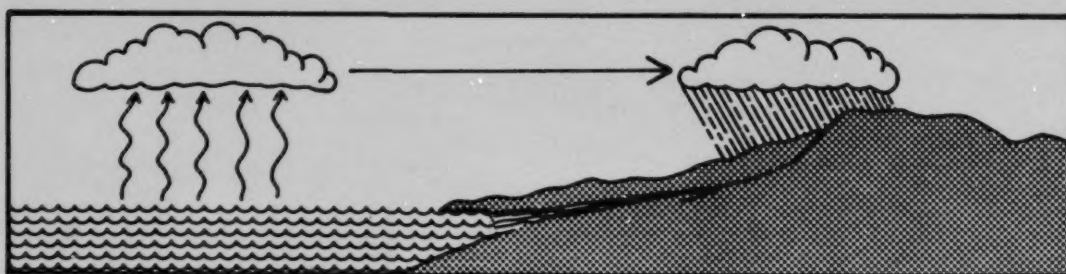


Figure 2. The Hydrologic Cycle

C. Water may be reused many times.

In some of its uses, water is removed from the hydrologic cycle. It may be taken into a plant or animal and, at least temporarily, become part of the organism. Or it may be "locked up" chemically with other substances in natural reactions or in manufacturing processes. This is known as *consumptive* use of water, in that the water used is, for a time at least, no longer available for other purposes.

In many instances, the same water is used again and again without being consumed. For example, a stream or river may be dammed to produce electrical energy. The lake formed by the dam may be used for fishing, boating, and other recreational pursuits. Further downstream, the water may be diverted to a city for home and industrial uses. Sewage and waste water may be purified and returned to the river to be used for irrigation still further down the valley. Some irrigation water evaporates from the soil and reenters the hydrologic cycle once more (see Figure 3, next page).

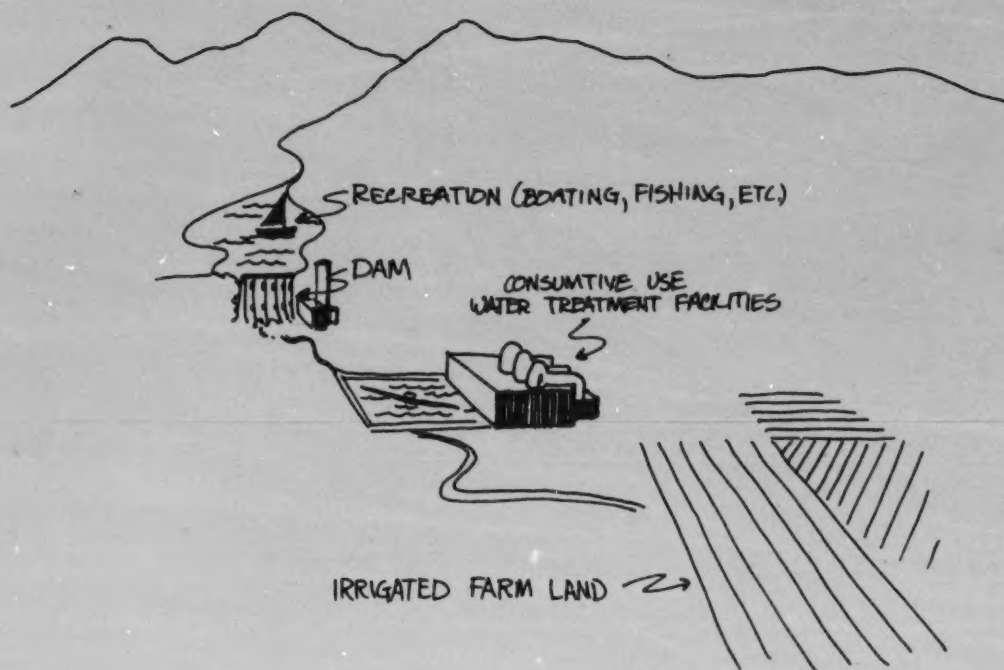


Figure 3. Reuse of Water Resources

BASIC CONCEPT NO. 5 – The quality of water is affected by the physical environment as well as man.

Understandings:

A. Precipitation is the initial source of all fresh water.

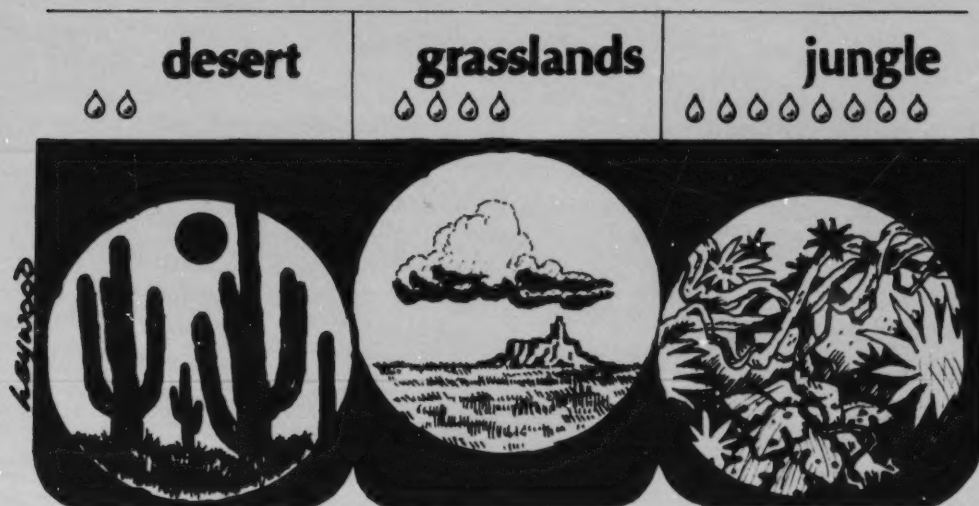
The water that falls as precipitation is nearly pure in its beginnings. As it falls, however, it usually picks up small amounts of dust, oxygen, carbon dioxide, and other foreign matter from the air. Still, it is relatively pure at the time it strikes the ground. From there on, it may affect, and be affected by, nearly every substance with which it comes in contact.

B. Water becomes less and less pure as it moves over the earth's surface.

As water moves over the land surface and through the ground, it may pick up a great variety of foreign substances. In its role as "the universal solvent," water dissolves many of the materials it touches. Depending upon its speed and volume of flow, it may pick up and carry foreign particles ranging in size from submicroscopic clumps of molecules to large boulders.

C. Water pollution may be defined as "any action that causes a deterioration of water quality."

Some of the substances picked up by moving water actually improve the quality of the water by giving it a pleasant "taste" and by adding minerals and traces of elements necessary to the health of animals and plants. Other foreign substances, such as



B. Large bodies of water have a moderating effect on climate.

Water has the ability to absorb great amounts of heat. Lakes and oceans act as reservoirs of solar energy, and thus help to moderate the climate of nearby land areas. Large bodies of water store up great quantities of heat in the summer and release it slowly during the winter, thus preventing extremes of air temperature over the neighboring land. Great ocean currents, such as the Gulf Stream and the Kuroshio Current, transport captured solar energy to lands far from the tropics.

The moderating effect of water is noticeably lacking in the desert areas of the world. The absence of lakes and streams, as well as water vapor in the air, results in greater heat from the sun's rays during the day and rapid escape of the warmth at night.

C. The life zones of the earth, to a great extent, are a result of the distribution of water.

The life zones of the earth (the deserts, the grasslands, the tropical jungles) are a result, to a great extent, of the location of the oceans, lakes, and rivers, and the distribution of precipitation. The amount of precipitation an area receives annually is affected greatly by the distribution of solar radiation, by the prevailing winds of the earth, and by the elevation of the land surfaces.

BASIC CONCEPT NO. 7 — Where water is scarce, priorities must be established for its use.

Understandings:

A. Early settlers believed in riparian water rights.

Early German, Dutch, and English settlers, most of whom came to the southwest from areas where there was plenty of water, brought with them a concept of water rights that held that water was owned jointly by the people who owned the surrounding land. This concept of "riparian" water rights created problems in the arid and semiarid western states. In the west, water is too often located in the wrong place, and must be transported in order to benefit the greatest number of people.

calcium ions and soluble magnesium and iron salts, cause "hardness" in water and make it less fit for man's use. Whether or not a particular dissolved substance should be considered a pollutant depends upon the nature of the substance, the amount (concentration) present, and the purpose for which the water is intended. The same calcium ions that make water less suitable for drinking and laundering, play an important role in normal plant growth when present in irrigation water. The proper concentration of fluorides in drinking water helps prevent tooth decay, but excessive amounts can cause unsightly staining of the teeth.

The U. S. Public Health Service recommends that domestic water supplies should not exceed 500 ppm (parts per million) of total dissolved solids (sea water averages about 35,000 ppm). The total dissolved solids (salinity) is the sum of all dissolved substances such as sodium, calcium, magnesium, potassium, sulfate, chloride, carbonate, bicarbonate fluoride, and nitrate ions. Certain metallic elements, such as lead and mercury, are highly toxic and have very low U.S.P.H.S. recommended limits.

D. Water pollution often results from the activities of man.

One of the undesirable side effects of human population growth and technological advancement has been the pollution of our streams, rivers, lakes, and even the sea. Excessive use of fertilizers and pesticides, inappropriate treatment of industrial wastes, oil spills (both accidental and deliberate), and indiscriminate dumping of raw sewage have made ecological deserts of many of our freshwater bodies and today threaten the world's oceans. Most of this man-made pollution is avoidable.

BASIC CONCEPT NO. 6 – Water affects our physical environment – the shape of the land, the climate, and the life zones.

Understandings:

A. Water shapes the face of the land.

Water, with the help of the wind, is constantly at work wearing down mountains, carving out canyons, building beaches, and filling valleys. This work involves both mechanical and chemical processes. The mechanical processes include the impact of raindrops and waves, the forces of running water (erosion and deposition), and the expansion involved as water freezes. The latter is an extremely powerful force capable of cracking huge boulders. Carbon dioxide dissolved by falling raindrops forms weak carbonic acid solutions that aid in the chemical decomposition of rocks, and water molecules themselves enter into numerous reactions with the minerals they contact. By the mechanical and chemical reduction of rocks into soil, water lays the foundation for life on land.

B. Arizona's water rights are based on history and law.

Prehistoric Hohokam Indians were the first Arizonans to "appropriate" water for beneficial use. Early "Anglo" settlers, attempting to establish riparian water rights, experienced considerable conflict over water use in the arid southwest. In 1851, the New Mexico territorial legislature decreed that:

"...all the inhabitants of the territory... who may be owners of tillable lands... shall have the right to construct public or private ditches (acequias) and to obtain water..."

The first Arizona territorial legislature, in 1864, adopted the code of laws written by Tucson's W. T. Howell, which declared:

"All streams, lakes, and ponds of water capable of being used for the purposes of navigation or irrigation are hereby declared to be public property, and no individual or corporation shall have the right to appropriate them exclusively to their own private use, except under such equitable regulations and restrictions as the legislature shall provide..."

This concept of "prior appropriation" holds that the public has a prior claim on our relatively scarce water supplies, and that private use must bow to welfare of the populace as a whole.

C. Priorities for water use have changed as our society and economy have changed.

Early Arizonans gave mining priority for water use. Later, mining was forced to give way to agriculture. Today, our priorities have changed further, and the law says that priority for water use goes: first to domestic and municipal uses, second to agriculture, and third to mining and other beneficial uses. The doctrine of prior appropriation is unchallenged in our state, and has been upheld in the United States Supreme Court.

SUGGESTIONS AND ACTIVITIES

Mathematics

A. STREETS AS STREAM BEDS

Determine if the street near the school is level from one side to the other. Stretch a cord across the street; allow each end to rest on the curb; pull string taut. Using a ruler or yardstick, measure the distance from the string to the street surface near the middle, $1/4$ of the way across, $3/4$ of the way across, near the curb. Diagram your findings. If measurements are the same in the middle of the street as at the curbs, the street surface is on a single plane. To measure whether the street is level longitudinally, use a small carpenter's string level and measure 50 feet down the street.

1. How can the shape, or level, of the street best be described? Can you make a cross-sectional sketch?
2. Does this shape assist in the runoff of rainwater from the street? Why? How?
3. What waste of water resources is represented by "storm water runoff"? Where does the water go in your town?
4. How could this waste be reduced? How could the waste water be utilized?
(Intermediate, Junior High)

B. STREAM VELOCITY

Place two stakes 5 meters apart along a stream or ditch. Drop a small, rubber ball into the stream above the first stake. Time the ball's movement between the two stakes. Repeat this procedure three times and compute the average. Record the velocity in meters/second. Repeat in various areas of the stream. Compare the results. Graph the various areas and velocities.
(Junior High)

C. VOLUME OF A SWIMMING POOL

1. Measure the average width, length, and depth of a swimming pool. Determine the number of cubic feet—how many gallons per cubic foot? How many gallons in the pool? If you use approximately 200 gallons of water per day (this includes indirect uses) how many people could the swimming pool supply for one day, one month?
2. Choose a small lake in or near your community. Repeat the above procedures. How many people could the lake supply for one day, one month?
(Junior High)

D. CALCULATE WATER USE

Calculate water use for various cities around the state. Use rainfall figures for each community. Each person uses 200 gallons per day. How many people in the

H. HOW MUCH IS WATER?

Take pieces of various food materials—meat, potato, apple, grapes, bananas, orange—peel skins from fruits and vegetables. Weigh each piece and record. Now place materials to dry in the sun or in an oven. If placed outside they must be protected from birds, insects, and other interference. When thoroughly dry, weigh each piece again and compare with the first weight. How much weight was lost? What percentage? If the meat weighed one pound, how much would it weigh after drying? (What do we call dried meat? — jerky.) What do *you* weigh now—what would you weigh if you were dried out completely? What material was lost in the drying process? Where did it go? Where will it go next?
(Intermediate, Junior High)

I. WILL IT BURN?

Fill a paper cup with water. Carefully place the cup over a flame. Can you boil the water? Repeat the procedure with vinegar. Does the same thing happen? Why?
(Junior High, High School)

J. MOISTURE AFFECTS TEMPERATURE

Select three coastal cities and three inland cities. Consult your local newspaper and other sources. Find monthly readings for the past year. Compute monthly mean highs and lows along with the monthly mean temperature. Compute the temperature range for each city (highest monthly mean minus the lowest monthly mean). Which city had the smallest temperature range? The largest range? What was the average temperature range for the coastal cities? The inland cities? How much difference between coastal cities? The inland cities? How much difference between coastal and inland? What property of water contributes to these results?
(Junior High, Intermediate)

K. RAINFALL AND ARIZONA VEGETATION

Have children, working in teams of two, make a transparent overlay of a large state map, indicating rainfall amounts for about 30 or more communities statewide. (State highway maps are available in quantity from the Highway Department. Rainfall data can be obtained from the Weather Bureau, the State Extension Service, or the Valley National Bank Statistical Review.)

Have children mark a pencil dot at the named communities and the rainfall amount (i.e., 14.31) beside the dot. Categorize four (or more) rainfall quantities, such as 0" - 5", 5.1" - 10", 10.1" - 15", and 15.1" plus. Using a different colored pen or pencil for each level, color the dots appropriately. Connect the dots with a light pencil line. Outline each zone with the appropriate color—do not run colored lines directly from dot to dot, but try to split the difference between dots of one color and those of another color, so as to generally outline an area of similar rainfall.

When all areas are outlined, color in each area so as to define a solid unit. You have now defined four, or more, areas of specific rainfall.

community? How many gallons used? Assume the rainfall is even over each city. Which cities probably use more water than falls in the form of snow or rain? What methods have been used, or are suggested, to correct "overdraft" problems in the arid areas? What methods could we propose to help solve this problem? Discuss suggestions. Research water use around the state. (Junior High, High School)

E. WATER REQUIREMENTS AND SURVIVAL

Usually the best thing to do when lost in the desert is to stay in one place and seek shade. Students can discover this fact by examining the following charts.

WATER REQUIREMENT CHARTS
(from "The Physiology of Man in the Desert"
by Adolph & Associates)

A. Number of Days of Expected Survival in the Desert, No Walking At All:

Available water per man, U.S. Quarts	0	1	2	4	10	20
Max. daily shade temp. F.	Days of expected survival					
120 degrees	2	2	2	2.5	3	4.5
110	3	3	3.5	4	5	7
100	5	5.5	6	7	9.5	13.5
90	7	8	9	10.5	15	23
80	9	10	11	13	19	29
70	10	11	12	14	20.5	32
60	10	11	12	14	21	32
50	10	11	12	14.5	21	32

B. Number of Days of Expected Survival in the Desert, Walking at Night Until Exhausted and Resting Thereafter:

Available water per man, U.S. Quarts	0	1	2	4	10	20
Max. daily shade temp. F.	Days of expected survival					
120 degrees	1	2	2	2.5	3	
110	2	2	2.5	3	3.5	
100	3	3.5	3.5	4.5	5.5	
90	5	5.5	5.5	6.5	8	
80	7	7.5	8	9.5	11.5	
70	7.5	8	9	10.5	13.5	
60	8	8.5	9	11	14	
50	8	8.5	9	11	14	

Make graphs showing this information.

NOTE: The importance of temperature reduction to the survivor is highlighted by the following in Chart A. Temperature—120°, water available—2 quarts, days of expected survival—2; reduce the temperature to 100° and 2 quarts of water will extend your life expectancy three times. This importance to a potential "survivor" cannot be overemphasized. Night travel, or better, no travel is stressed.

(Junior High, High School)

F: HOW MUCH WATER DOES A TREE THROW AWAY?

Using medium to large plastic bags, with a marble-sized pebble inside so that there is a collecting point, have each student cover several large leaves or leaflets on a tree. (You may have students use a variety of trees for interesting comparisons.) Fasten bags tightly, so that moisture does not escape from the bag. Leave in place for 24 hours. Collect the bags by clipping the branch just above the bag. Have each student record the number of leaves or leaflets in his bag. Have students estimate the number of leaves or leaflets on the tree. Determine the amount of water in each bag. With this information estimate the amount of water that evaporates from the tree in 24 hours.

Fill in the following information:

Type of tree _____

Number of leaves or leaflets covered _____

Weight of plastic bags, moisture, and leaflets _____

Weight of empty bags and leaflets _____

Weight of water from bags _____

Average weight of water per bag _____

Number of leaves or leaflets on a branch _____

Number of branches on the tree _____

Weight of water that had evaporated from the tree _____

Volume of water that had evaporated _____

Why would the amount of water loss from a tree be of concern to some people? Name the people and state why they would be concerned.

Make a list of the conditions that would cause the amount of water to vary.

(Junior High, High School)

G. MAN AND HIS DEMAND FOR WATER

Man seems to have an ample supply of usable water, except for three factors: very unequal distribution, rapidly growing demand, and increasing pollution of water supplies near urban centers. Distribution is a natural problem but the other two are clearly man caused. In Arizona we face all three problems.

The table below shows how the demand for water has increased in the United States this century.

AVERAGE DAILY WATER USE IN THE UNITED STATES

Year	Type of Use (billion liters per day)			
	Domestic	Agriculture	Industry and Steam Electric Utilities	Total Water Use
1900	19	76	57	152
1920	32	212	103	347
1940	50	269	198	517
1960	106	510	605	1,221
1980	127	673	1,046	1,846

1. According to the data in the table above, what trend is evident in water usage?
2. Which activity used the most water in 1900? 1960? 1980?
3. Which category increased its demand for water the most between 1920 and 1960?
4. Today, twice as many people live in the U. S. as did in 1920. How does the increase in water use relate to the increase in population during this century?
5. Research U. S. population in 1900, and the population expected in 1980. How many liters of water were used in 1900, 1920, and 1980 per person?

(Junior High, High School)

The figure below shows the problems of natural water shortage and water pollution for our country.



Present and future water deficit regions compared with megalopolis regions, having high water and air pollution. (Commission on Population Growth and the American Future 1972, pp. 33-46)

1. In which areas of the country will natural water shortage become a problem?
2. In which areas of the country will polluted waters become an increasing problem?
3. In which areas of the country will both natural shortage and pollution become a problem?

H. YOUR WATER BILL

Obtain a copy of your water bill. Most water bills are expressed in terms of the number of thousand gallon units used. Does the amount shown on the bill reflect the amount of water you think you use? How could you check? Devise methods to check your daily water use. What might explain discrepancies between your bill and what you found? How much water can a dripping faucet, leaking one drop per minute, lose? Set up an experiment to give you this information and test it for one hour. Calculate the amount of water lost for one month. At the rate indicated on your bill, how much does that loss cost? The average cost of water across the country is about .00087 cents per gallon for amounts up to 5000 gallons. The rate generally goes down as more water is used. Does this help conserve water? How can water rates be made to affect water use?

(Junior High, High School)

Social Science

A. COMPARE YOUR STATE

Contact a teacher from another state. There are many correspondence lists in educational journals. Choose a community that has a radically different climate than your home. (Check to see if any of your students are from that area.) Set up a correspondence program to compare your climate with the climate of the other city. Find average temperature, humidity, snowfall, etc. Display each characteristic using appropriate graphs, charts, tables, and illustrations. Exchange this information with your "sister" class. When you receive their information, hypothesize what conditions exist in the "sister" community. Try to predict what general types of plants and animals would be found there. Are there mountains, rivers, lakes, oceans, etc. Send your hypothesis to the other class. They will also be making such a hypothesis and sending it to you. Send them a report of where they were right and where they were wrong. You will receive their information telling you how well you were able to visualize their community.

(Intermediate, Junior High)

B. MAP THE CRACKS

Obtain a map of the neighborhood served by your school. Have each student mark where he/she lives. Assign each student a street or block. They are to look for cracks in the sidewalks, cracks in the streets, cracks in buildings, vacant land, and large buildings or structures of great weight. Have students locate these things on the map in one color. Obtain locations of city and/or private wells from the local water company. Either mark these wells on the map with a different color or make clear acetate overlays of cracks, buildings, lots, and wells. Does any pattern (or patterns) between the numbers of cracks and buildings appear? How about cracks and vacant lots? Cracks and wells? If some correlations do occur, what do you think may be the causes? What further information would be needed to come to a reasonable conclusion (length of time structures in place, depth of wells, how long they have been pumping, what is present water level, what was original water level, etc.)? What values can this information produce?

(Junior High, High School)

C. HOW CLEAN IS CLEAN?

Have your students read and react to the following situation:

Oxbow is a community located amid the rich forest lands of the Olympic Peninsula in Washington State. It is the largest town on the Peninsula and recently sent a local man, Carl Sears, to Washington, D.C., as congressman from its district. Before his election, Sears was a lawyer in Oxbow and is well-acquainted with the community's people and problems.

Oxbow's economy depends primarily upon a paper mill which employs several hundred workers and indirectly supports much of the town's business establishments through its payroll. Because Oxbow is located on the Hemlock River, with easy access to Puget Sound and the Pacific Ocean, its second largest industry is salmon fishing.

Recently, a bill was introduced in Congress to impose stricter air and water pollution control standards. To meet these standards, the Oxbow mill would have to spend a substantial sum of money and thereby reduce its profit margin. The mill owners have asked Sears to oppose the bill because, they say, the profit loss will force them out of business and hundreds of Oxbow workers will lose their jobs. The president of the local union also opposes the bill and has threatened to withdraw his support for Sears in the next election if the congressman votes in favor of the stricter regulations.

On the other hand, townspeople dependent upon the Oxbow salmon industry are urging Sears to vote for the new bill. For a long time, they have opposed the pollution of the Hemlock River because they believe it is destroying the salmon run. In fact, they assert, if water-control measures aren't imposed soon, they will be forced out of business.

The vote will be close. Sears is under considerable pressure from his constituents on both sides of the issue.

Ask each of your students to imagine he or she is Sears. As Sears, how would the student go about arriving at a decision? Questions to be considered include:

1. What issues are at stake?
2. What kinds of evidence or data should Sears seek to help him decide? How could he evaluate its validity?
3. What are the trade-offs involved in Sears's decision?
4. Are there any alternatives to "clean up or close up" for the mill owners? For the fishermen?
5. As Sears, how would you vote? Explain the reasoning behind your choice.

(High School)

D. COMMUNITY LAND USE

Divide the class into four groups. Each group will study your community's land use in one of four time periods: the present; 25 years ago; 50 years ago; and 100 years ago.

Group members will collect data from community records, including old maps and photographs, and make a map illustrating the land-use pattern during the period they are investigating. All four maps should be made to the same scale.

After the maps are completed, students will compare the land-use patterns and discuss the changes.

Has the community's size changed? If so, how?

Has the land-use pattern changed? What uses have increased? What uses are decreasing? Have any of the original uses disappeared? What changes in water use can be documented? Are we using more water per capita, or less?

Ask students, either individually or in small groups, to interview residents who have lived in the community for from 25 to 50 years to find out their perceptions of changes. If possible, the interviews should be recorded on tape.

From the interviews, students can determine:

1. What was the general ratio of people who believed the land-use changes were harmful as compared to those who believed they were helpful?
2. What reasons did the residents give for their opinions on the changes?
3. Do any residents who believed a change would be helpful at the time it took place now think it was detrimental to the community? Do any of them believe a change they originally thought was harmful has turned out to be beneficial?

(NOTE: Students should consider facts which might affect the validity of the data obtained from responses to their questions. Most people don't like to admit they were mistaken.)

The class then should discuss what land-use changes appear to be coming in the future. Do the students think these will be helpful or harmful? Ask them to state reasons and criteria to support their opinions. Can the students suggest mechanisms available to insure that most changes will be beneficial? What future water-use patterns can you predict? How does this relate to the Central Arizona Project?

(Junior High, High School)

VARIATION:

Have your students make or look at a map of their community which identifies current uses of the land (shopping areas, parks, streets, industrial sites, etc.)

Using the map, students should compile a table showing the amount of land devoted to each type of use. You may wish to divide the class into small groups and ask each group to calculate the acreage devoted to a specific use.

After the table is finished, discuss some of these questions:

1. What kind of use occupies the greatest amount of land?
2. What kind of use consumes the most water? The least?
3. What portion of the land is devoted to green or open space? Is it enough? How do you decide?
4. Is there a pattern to the land use or does it appear to have developed by chance?
5. Does your community have a land-use plan? If so, what are the goals of the plan and how is it put into effect? If there is no plan, are any steps being taken to develop one?
6. Is water use and availability a part of these plans? (High School)

E. LOCAL RECREATION PREFERENCES

Have students brainstorm a list of questions that could be used in surveying the use of local recreation facilities. Sample questions might include:

1. Does your family own a camper, tent, or cottage?
2. Have you been to (name of area)?
3. If yes, have you been there within the last year?
4. Do you go to any other recreation facilities in your area?
5. If yes, which ones?
6. Does your family go swimming at _____?
7. Does your family go hiking at _____?
8. Does your family go fishing or hunting at _____?
9. What do you like most about _____?
10. What do you like least about _____?
11. Was there a fee charged for use of the facilities at _____?
12. Would you contribute \$10 to the building and/or maintenance of the facilities at this area?

From the list of questions, have students prepare and distribute a questionnaire on recreation. They are to put the data collected into a table which compares the differences in the responses to the questions by age groups. For instance:

Question	Under 15				16-49				Over 50				Total Response
	Yes		No		Yes		No		Yes		No		
	#	%	#	%	#	%	#	%	#	%	#	%	
No. 1													
No. 2													
Etc.													

Using data from the table, ask each student to write a summary statement on the differences in attitudes among the different age groups. Discuss these questions:

1. Do all age groups prefer the same types of outdoor recreation areas or activities?
2. What might cause differences in preferences?
3. What type of recreational areas are in the greatest demand? Are these areas adequately supplied?
4. How important is outdoor recreation to your community's economy?
5. How large a part does water take in recreation?

VARIATION 1:

With a mail-order catalog as a reference, ask students to calculate the cost of camping for a family of four by means of backpacking; car camping with a tent; and car camping with a trailer or motor home.

VARIATION 2:

Select a recreational area in your state, preferably near your school. A city park would be adequate.

Assign students to visit the area and photograph, write down, or tape record the variety of uses made of the park. Uses would include such things as picnicking, boating, sports, meeting rooms, museums, camping, bike riding, swimming, and fishing.

In class, ask students to prepare a report, booklet, bulletin board, mural, or other project which depicts the diversity of uses they have found. Each student then should select one use and do a report (in any medium) on what would happen if this use were eliminated. They should consider these questions:

1. Who would be affected?
2. Would different age groups be affected differently?
3. Would anyone benefit?
4. Would the site benefit?
5. Who would be harmed?
6. Would the effects be different if the use chosen were the *only* use made of the area? How?

If you prefer, students could do reports describing services or activities that could be added to make the area a better place. They should consider:

1. Who would be served by these additions?
2. Who might be harmed by these additions?
3. What would the additions cost?
4. Who *should* pay for these facilities?
5. Who *is* paying for existing facilities?

(High School)

F. FOR BETTER OR FOR WORSE?

Present this situation to your students:

Some time ago, Inter State Paper Company officials, in order to comply with new air and water pollution regulations, hired pollution-control technicians to study the company's manufacturing operation. The technicians now have presented a pollution-reduction plan to Inter State's board of directors. The new process would reduce odorous gas emissions (air pollution) by 95 percent and the B.O.D. (a measure of water pollution) added to the river by 94 percent. The control measures would cost an estimated \$11 million to \$12 million but, with some state assistance, the company would be able to install the new process within a few years.

The new process would have the additional benefit of enabling the company to recover and reuse or sell most of the waste products now dumped into the river and air.

There is one problem. The new process ~~would~~ require substantial amounts of electricity. The power can be obtained from a coal-fired plant that would have to be constructed. This plant also would require pollution-control devices but it would have the advantage of generating enough new electricity to meet the increasing energy needs of the community as well as those of the paper plant. Coal for the plant most likely would come from strip mining but this issue will be decided by pending federal legislation.

Inter State has proposed an alternative to the coal-fired plant. The company believes it can supply the additional electricity needed by installing a wood and wood waste-fired boiler in its plant. Drawbacks are that this boiler would cost three times as much as one using only coal or gas and it would not produce any excess power for the community. Inter State would have to raise prices for its products to get the necessary funds and the community's energy needs would not be met.

After students have familiarized themselves with the situation, discuss these questions:

1. What are the advantages and disadvantages of Inter State producing its own energy?
2. What are the advantages and disadvantages of a new coal-fired power plant?
3. If the company installs its own boiler and then raises its paper prices, what effect might there be on sales? Would you be willing to pay more for your paper? Would you be willing to use less?
4. What implications does the choice of a power source have on the future of the company and of the community?
5. What are the trade-offs involved in this situation?
6. What options are available to the community?
7. If you lived in this community, which option would you choose? Why?
8. What water pollution changes might occur with the change-over?
9. What is B.O.D.?

(High School)

Fine Arts

A. WATER PANTOMIME

Have children act out various scenes that demonstrate interactions between water and such things as plants and animals—including man.

Some suggestions:

What makes a thirsty animal happy?
What happens when you water a plant?
A rainy day at school.

Have children work in small teams to portray these interrelationships.

(Primary)

B. WATER-USE MURAL

Using the data gathered in activity Mathematics-C, have the students make a mural or collage of the ways they use water. Children can draw and paint or cut out pictures from magazines to add to the display. (Primary, Intermediate)

Language Arts

A. HAPPY/SAD

Bring in a series of pictures which include water in the environment—one perhaps where children are playing in a stream, one showing polluted water, one with rain or snow falling on plants or on children. Ask children to pick out the pictures that make them feel happy and tell why. Ask them to choose the pictures that make them feel sad and explain why. (Primary)

B. CINQUAIN ELOQUENCE

Cinquain poetry is simple to construct and it provides a unique opportunity for children to express their perceptions and feelings in a creative way. The cinquain poem has five lines: Line 1 — one word that identifies the subject or title; Line 2 — two words that explain the title; Line 3 — three words that show action; Line 4 — four words that complete line three; Line 5 — one word which also explains the title. Topics for cinquain about water might be: rain, snow, river, creek, lake, falls, canal, flood, pollution, evaporation, transpiration, etc.

Stream

Cool, clear
running, rocky, rapids
refreshing, rewarding, fresh, fulfilling
water

Water

Gurgling — still
flowing, standing, living
we all need you
stream

Science

A. WATER PLAY

To truly understand the concept of water and its properties, children need to have many experiences with water. The best way for young children to do this is through unstructured water play. Provide the children with pans, cups, spoons, tubes, corks—whatever you can easily find. Provide a place where spills won't do damage and

let the children play. Through this play children will gain some ideas about water and its properties. Don't try to teach these concepts now—this comes later. But, when it is time for more formal instruction, children will have some concrete experiences to relate back to.

(Primary)

B. WHY ARE CACTUS FAT?

Wet two handkerchieves or paper towels of the same size. Crumple one into a round ball. Stretch the other out flat and straight. Pin both to a coat hanger. Ask the children to predict what will happen if this is hung out in the sun. Observe. Which handkerchief dried first? Which handkerchief is shaped most like a cactus? What conclusions can you make about the fat shape of many cactus? What about prickly-pear cactus—they are flat? What does it do to conserve water? Do all cactus conserve water in this way too?

(Primary)

C. WHAT HAPPENS WHEN WATER EVAPORATES?

Evaporation is part of the water cycle. Not only does it put water back into the air but it helps cool things as well. Have children wet a cloth and place it on their skin. Remove the cloth. Blow on the spot. What happens? How does this help us? What happens if you blow on a spot which was not dampened? What is the difference? Where does evaporation occur in the water cycle.

(Primary, Intermediate)

D. HOW DO WE USE WATER?

Make a class list of ways the students use water. Have them individually think through a day to come up with their own list. Have children take lists home and ask parents to add to the list. Summarize.

(Primary, Intermediate)

E. WHERE DOES WATER COME FROM?

Duplicate the two circles below and have children cut out appropriate segments. When circle B is attached with a brad to the back of circle A they have a model of the water cycle. Follow the water drops to help children begin to understand the cycle of water on earth from ground water to water in lakes, streams, and oceans, evaporation into the air, and moisture coming back to earth again.

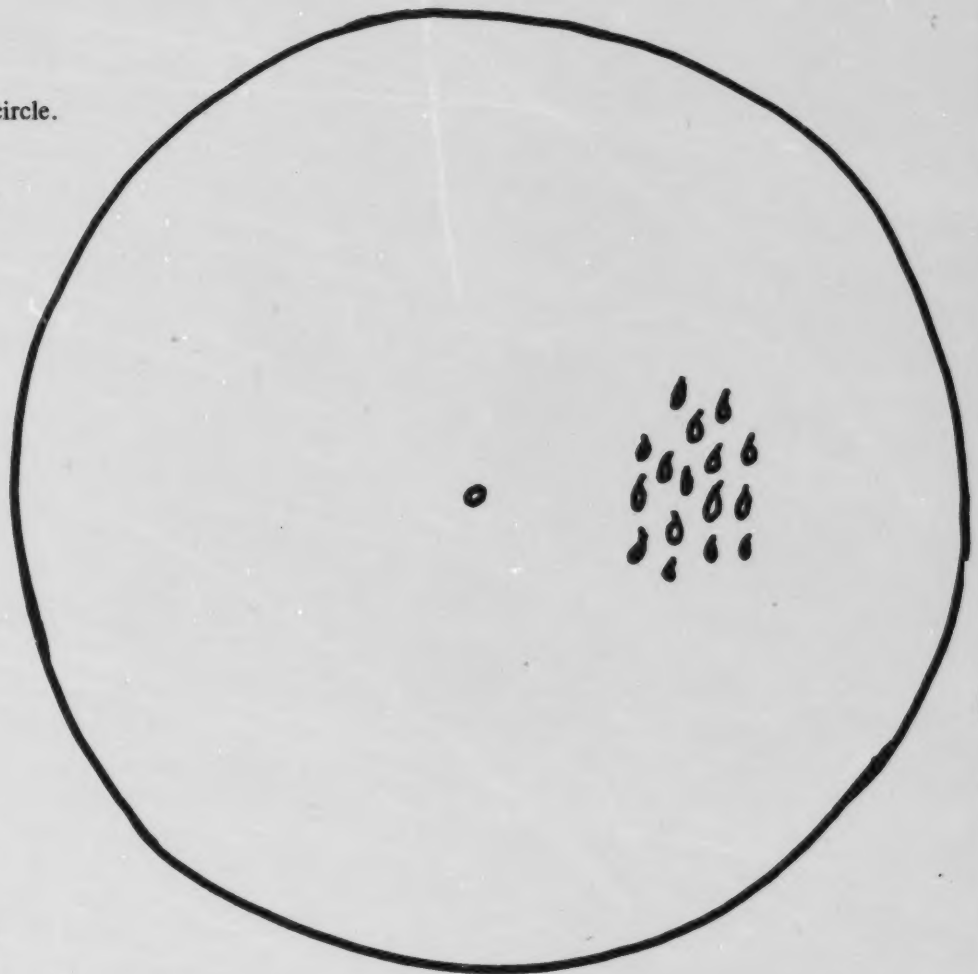
(Primary, Intermediate)

WATER CYCLE WHEEL – PART A

Cut out whole circle.

Place Part A on
Part B.

Put brass
fastener
through
center
hole.



by
Marilyn Laskey

—Interdisciplinary Environmental Education Project, K-12, ESEA, Title III, Broward
County, Florida.

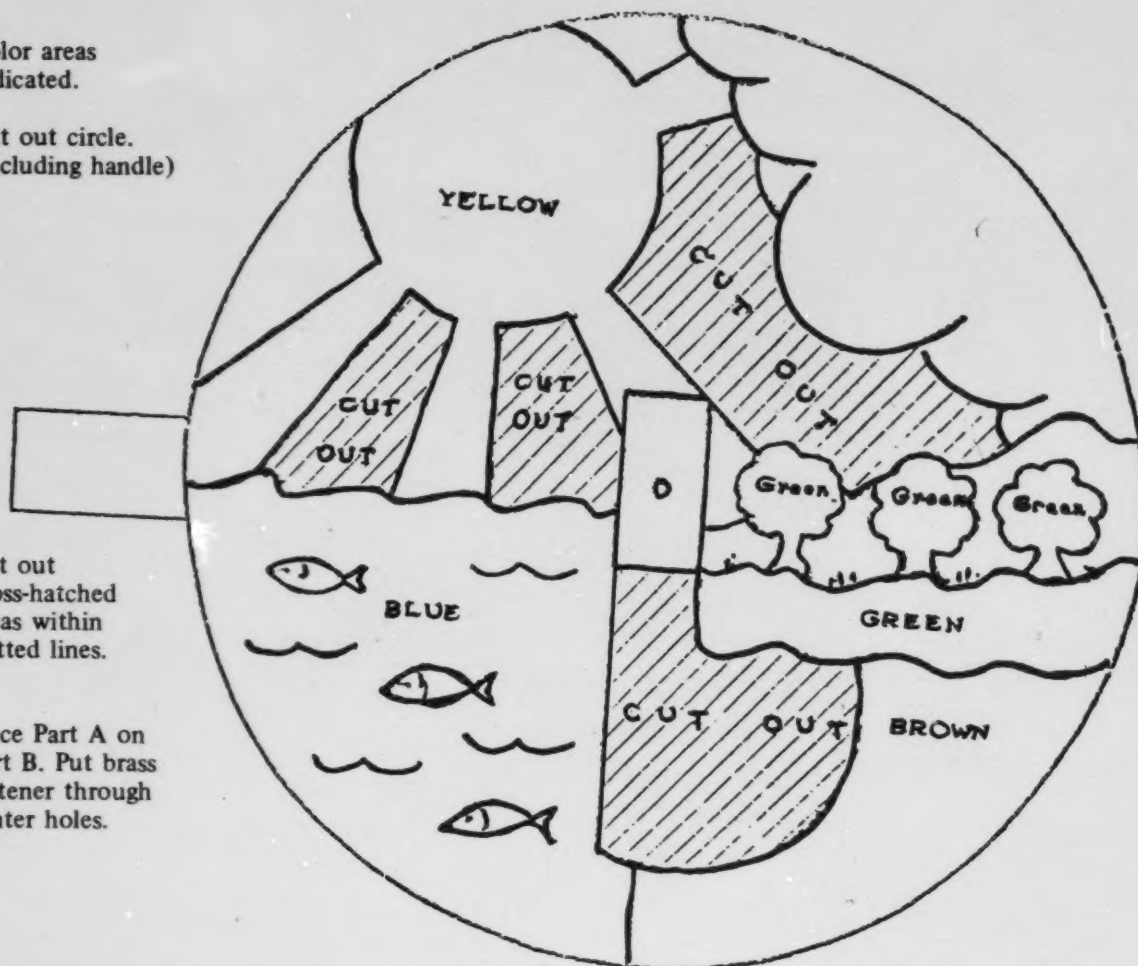
WATER CYCLE WHEEL - PART B

Color areas indicated.

Cut out circle.
(including handle)

Cut out
cross-hatched
areas within
dotted lines.

Place Part A on
Part B. Put brass
fastener through
center holes.



F. THE WORLD'S WATER SUPPLY

The following demonstration points up the relative amounts and availabilities of the world's water supply. Do the activity—or better still, have children do it—carefully.

1. Fill a container (perhaps an aquarium) with five gallons of water. This represents the total amount of water in our ecosystem.
2. Remove 2-1/4 cups of water from the large container. This represents the total supply of *fresh* water in the system. Put this in a clear container; place next to the aquarium.
3. Take 1-3/4 cups of water from container No. 2. This water represents the water locked up in polar ice caps, glaciers, topsoil, and suspended in the atmosphere. Put the 1-3/4 cups of water in a separate container alongside the others.
4. There is 1/2 cup of water remaining from the original 2-1/4 cups removed from the tank. This 1/2 cup, less 5 drops, represents expensive, inaccessible, and polluted water.
5. Using a medicine dropper, remove the 5 drops of water and place them in another container. These 5 drops of water represent the fresh water supply that is available and usable to man.
6. Put different colors of food coloring in the jars or bottles representing the total *fresh* water supply, the locked up water, the polluted or inaccessible water, and the fresh water that is available to man. Display and identify.
 - a. What uses can man make of the water represented by that in the aquarium? How?
 - b. Does man ever get to use the locked-up water? When? How?
 - c. What do we mean by expensive water? Inaccessible water?
 - d. Which parts of this water recycle? Does the water in the aquarium change to usable water? What is the process? How is this water replaced so as to maintain the balances we have modeled? (Intermediate, Junior High)

G. HOW DOES THE VOLUME OF WATER AFFECT TEMPERATURE?

Place two cups of water in a container—heat over a steady flame. Check the temperature each minute. Keep a record of temperatures up to full boil. Repeat the experiment using four cups of water—repeat with one cup of water. Does the temperature change more rapidly in one experiment? Which one? Which temperature changes were slowest? Make a graph of all temperature readings. Record the physical appearance of the water at each reading. Is there a correlation between temperatures and appearance? (Intermediate, Junior High)

H. HOW MUCH IS WATER?

Take pieces of various food materials—meat, potato, apple, grapes, bananas, orange—peel skins from fruits and vegetables. Weigh each piece and record. Now place materials to dry in the sun or in an oven. If placed outside they must be protected from birds, insects, and other interference. When thoroughly dry, weigh each piece again and compare with the first weight. How much weight was lost? What percentage? If the meat weighed one pound, how much would it weigh after drying? (What do we call dried meat? —jerky.) What do you weigh now—what would you weigh if you were dried out completely? What material was lost in the drying process? Where did it go? Where will it go next?

(Intermediate, Junior High)

I. WILL IT BURN?

Fill a paper cup with water. Carefully place the cup over a flame. Can you boil the water? Repeat the procedure with vinegar. Does the same thing happen? Why?

(Junior High, High School)

J. MOISTURE AFFECTS TEMPERATURE

Select three coastal cities and three inland cities. Consult your local newspaper and other sources. Find monthly readings for the past year. Compute monthly mean highs and lows along with the monthly mean temperature. Compute the temperature range for each city (highest monthly mean minus the lowest monthly mean). Which city had the smallest temperature range? The largest range? What was the average temperature range for the coastal cities? The inland cities? How much difference between coastal cities? The inland cities? How much difference between coastal and inland? What property of water contributes to these results?

(Intermediate, Junior High)

K. RAINFALL AND ARIZONA VEGETATION

Have children, working in teams of two, make a transparent overlay of a large state map, indicating rainfall amounts for about 30 or more communities statewide. (State highway maps are available in quantity from the Highway Department. Rainfall data can be obtained from the Weather Bureau, the State Extension Service, or the Valley National Bank Statistical Review.)

Have children mark a pencil dot at the named communities and the rainfall amount (14.31) beside the dot. Categorize four (or more) rainfall quantities, such as 0" - 5", 5.1" - 10", 10.1" - 15", and 15.1" plus. Using a different colored pen or pencil for each level, make the dots appropriately. Connect the dots with a light pencil line. Outline each zone with the appropriate color—do not run colored lines directly from dot to dot, but try to split the difference between dots of one color and those of another color, so as to generally outline an area of similar rainfall.

When all areas are outlined, color in each area so as to define a solid unit. You have now defined four, or more, areas of specific rainfall.

Using a vegetative map (obtainable from the Agriculture Extension Service at the University of Arizona), have children place their overlays on the vegetative maps. Discuss correlations—explain that the correlations could be much more exact by adding more rainfall data points to their overlays.

What do the overlays show us? If we have a pinon-juniper or pine-fir forest in Arizona, how much rainfall is necessary? If you are using the Statistical Review data, look at correlations between rainfall and elevation. Why is the rainfall in Winslow only 7 plus inches when in Payson the rainfall is 20 plus inches, and they are both almost the same elevation? If you were going to "dry-farm" a crop of wheat or corn, what rainfall would be the minimum requirement? (Wheat and corn are grasses)

Obtain a map showing archeological sites in Arizona. What correlations can you see with the vegetative map? To rainfall?

Compare a soil map to your overlay or the vegetative maps. What correlations are evident between soil and vegetation? Between soil and rainfall?

If you want to carry this a step further, you can relate many species of wildlife very directly to rainfall and vegetation. Obtain a copy of "Recent Mammals of Arizona," by Cochrum, from the library. Look at the habitat maps of such species as the Abert squirrel, the California leaf-nosed bat, the Mexican wood rat, and the Mexican vole. Make overlays of their habitats and compare to rainfall and vegetation maps. The correlations are dramatic in many cases.

How important is rainfall to living things in Arizona?

(Intermediate, Junior High, High School)

L. IS THERE WATER IN AIR?

Air is a mixture of certain elements and compounds such as nitrogen, oxygen, and carbon dioxide. But is there water in air? Try these experiments to find out.

1. Take some water and mix in a little dirt. Put the dirty water into a small, shallow dish. Observe the dish for several days. What happens? Where does the water go? Allow the dish to completely dry. Record the amount of water used and the length of time for it to disappear. Did you increase or decrease the water vapor in the air?
2. Take a glass and place it in an empty fish bowl. Fill the glass with crushed ice and keep it filled. What happens on the outside of the glass? How much water did you get? Record the length of the experiment and the amount of water produced. Where did the water come from? Did you increase or decrease the amount of water vapor in the air? If you keep on adding ice, will the process continue? How long would it take to put 1/4-inch of water in the bowl? (estimate)

(Junior High)

M. CREATE AN ARTIFICIAL LAKE

Using a glass jar or large glass, fill the container with water and then add some soil. After the soil has settled completely and the water is clear, carefully add one or two ice cubes. What happens to the "lake"? Why? Can you think of a situation in nature where this might happen? Do you know a place in Arizona where this happens? What would this do to the drinking water of a city using this lake? Why would this action be important to aquatic insects or other animals? (Junior High)

N. FINDING WATER IN THE DESERT

What clues can lead you to water in the desert? Here are some that you might investigate on a field trip:

1. Watch for animal trails which may lead to water.
2. Birds will often circle over water holes. Quail travel to water in late afternoon and often roost in brush or trees near water. Doves fly to water morning and evening.
3. Seeps and drips may be found in conjunction with rocky cliffs for some time after rains.
4. Dry stream beds may have water near the surface. Dig at the lowest point on the outside of a bend in the stream channel. Dig until you hit wet sand. Water will seep into the hole. Let the water settle and clear.
5. Look for "indicator" plants which grow only where there is water: cottonwoods, sycamores, willows, hackberry, saltcedar, cattails, or arrowwood. Dig near these.
6. The immature stalks of Agave, Yucca, Mescal, and Sotol contain moisture (they look like asparagus tips), or the main stalks may be split open and the pith chewed for moisture. The barrel cactus contains a high degree of moisture, but it is not possible to squeeze out water, as the mucilaginous, acrid juice thickens rapidly. (Junior High, High School)

O. THE SCHOOL AS A WATERSHED

Have the class conduct a study of the school building as the beginning of a watershed. This is best done during a rain, if possible. Examine the roof of a building from the ground. How many surfaces has the roof for shedding water? Walk around the building. Locate all the rain gutters. Does each surface have one or more rain gutters? What happens if there are no rain gutters? Find the downspouts. Trace the route of water from the various surfaces of the roof to the rain gutters, to the downspouts, to the streets, and to the storm sewers. Observe the school yard for low spots where water collects after rains. (Junior High)

P. WHERE DID THE WATER COME FROM?

Using medium- to large-size plastic bags, (9" x 11", or so) have children place bags over the ends of branches, leaves, or clumps of vegetation. Make sure the area is in the sun and that it hangs down. Secure the bag around the stem or branch after placing a pebble in the bottom of the bag. Choose a variety of plants and a variety of leaf sizes (mulberry, mesquite, or palo verde). Leave for 30 minutes. Gather the bags and discuss the amounts of water in each. Measure amounts from a variety of plants. Which plants produced the most water? Why? Where did the water come from? Where would it have gone if we had not gathered it in the bags? Compare results with shaded branches. Try putting on bags at nightfall and leaving them until morning. See activity N for additional activity.
(Junior High, High School)

Q. PERSONAL HYGIENE

Have each student make a list of all water needs for personal hygiene uses (hair washing, showering, toilet flushing, etc.). Have the class devise simple methods to measure these water uses. Have each student record the water used for these activities for the period of one week. Record amounts per day. Discuss hygiene needs in relation to water used. What water used could be eliminated or reduced? What is your family's daily usage? What activity is the greatest user? Check your family water bill for costs per 1000 gallons. Check with the City Water Department for an estimated cost to produce 1000 gallons of water for your home. Contact the City Waste Disposal or sewage treatment plant for costs to treat 1000 gallons of sewage. Discuss the total costs to the people of your city.
(Junior High, High School)

R. WHAT IS PRIMARY TREATMENT?

Visit your local sewage treatment plant and diagram the treatment process. How does this method work? How are organic materials removed? What is done with this material? What is primary treatment? How effective is primary treatment? Does your community provide secondary treatment? What does secondary treatment do? How does the combination of primary and secondary treatment compare with natural water purification? Are there further treatments which can make water more pure? Are these advanced techniques economically feasible? What does it cost your community for primary treatment of sewage per 1000 gallons? Secondary treatment? Who pays for this? What are some materials in raw sewage that are difficult to remove? Who puts these materials into the system? Do they pay the same rates for this service as residential users? Should they?
(Junior High, High School)

S. HOW CAN IMPURITIES IN WATER BE REMOVED?

Students should design their own systems for removing impurities from water. Make up a gallon of dirty water—use fine silt or clay. Give each student a small quantity of the dirty water and see what means he/she can devise to purify it. Here are some possible ways to go:

1. Take a small can; punch small holes in the bottom. Put a layer of small gravel in the bottom followed by a thicker layer of clean sand. Pour water through this filter. How has it changed?

2. Try filters made of cloth and/or paper (not filter paper). Run water through filter materials more than once. See who can attain the cleanest water in a given length of time.

Now, make up a solution of salt water—repeat the experiments. Taste the water before and after—has there been a change? How can you get rid of the salt? Try it. How does nature remove impurities from water? What are some of the advantages—disadvantages of having nature do this job? What are some things that nature may not be able to handle?

(Junior High, High School)

T. WATER NEEDS

Investigate the life histories of several desert animals. What adaptations have they made to enable them to live with little or no free water? List some adaptations, and illustrate obvious physical and behavioral adaptations with drawings, charts, or graphs.

(High School)

U. WHAT'S A WATERSHED?

1. Using topographic maps of a familiar area, find a creek. From a given position follow the creek and all of its tributaries upstream until they end. Mark the highest upstream point of each. Draw lines from point to point. These are the boundaries of the watershed supporting the point of beginning. Define a watershed. What is its importance? What are some factors that could effect a watershed? What about range or forest fires, logging, subdivision construction, or overgrazing? What would be their effects upon this watershed? In what ways could political boundaries affect watersheds? (Who manages the land.) How would such boundaries affect watershed management?
2. On a field trip, find and measure a mini-watershed. On a small slope, trace the small drainage patterns to their upper limits. Determine the divide and mark with piles of rocks or other markers. Outline the watershed. Determine how many square feet (or meters) are involved. If the rainfall of this area is approximately _____ inches (or centimeters) per year and if 100 square feet will produce 740 gallons of water per 1-inch of rain, how much water is handled by this watershed in one year?

43,560 square feet in one acre

1 acre-foot of water (1 acre covered 1-foot deep) equals 325,828 gallons

3. Look at a larger map or maps of Arizona. Try to outline the watershed for a major lake such as Roosevelt Lake, Horseshoe Lake, Coolidge Lake (for Coolidge you will need a map of New Mexico also). How many square miles are encompassed in one of these watersheds? Look at rainfall records for various spots within the watershed. Average them out. Calculate a rough estimate of amount of water handled on that watershed in one year.
4. From your starting point in either 1, 2, or 3, follow the flow downstream. Where does it go? Who uses it? For what purposes? Where does it eventually end up?

(High School)

V. WATER, WATER EVERYWHERE, BUT WHERE DOES IT COME FROM?

Many of us take our supply of water for granted. We're pretty confident that when we turn on the faucet, water will come out. But where does it come from? How much does it cost? Will the supply last forever?

Call, visit, or read about your local water treatment plant. Here are some questions to inquire about:

1. Where does my water come from?
2. How is the water treated before it reaches me?
3. How does the water reach my home?
4. Is there enough water for all the people and industries in the area?
5. How much does the water cost?
6. Will there be enough water if the population grows at the same rate? At a greater rate?
7. What are some special problems about water in this area?
8. Is there enough water to continue present agricultural practices?

Use your information in a class discussion on local water resources. Make a chart showing the flow of water in your area from its source to your home.

Using the chart as an outline, do a large mural showing the flow of water to your home.

An extension of this should be: Where does it go from here? Where does it go after I have used it? What happens to the water I use in my swimming pool? The water that I use to water the lawn? Wash my car?

Follow this step by step. Do a flow chart from your home to the sea. Show where, at certain steps, some of the water is recycled into the system (evaporation from pools, irrigation, sewage ponds, etc.). Extend the first mural you did to include your use and where the water goes from there.

Is water ever "lost"? Is water a renewable resource? How far does water travel to you? From you to the sea? From the sea back to you? How long may parts of this cycle take?
(Junior High, High School)

Vocational

A. WATERSHEDS

Have students map and outline major drainages in Arizona. Trace the flow of each from its source to the Gulf of California. Each watershed could be colored differently and when one joins another a line of that color could continue on to the Gulf. Suggested rivers and watersheds: Colorado, Salt, Verde, Santa Cruz, San Pedro, Gila, Big Sandy, Bill Williams, Little Colorado, Kanab Creek, Hassayampa, Agua Fria, San Carlos, White River, Black River, San Simon Creek.

Which river systems start outside of Arizona? Find their sources. Which is the longest river? Which is longest but entirely within the state? What directions do rivers flow? Which ones flow north?
(Junior High, High School)

VOCABULARY

deposition – The reverse of erosion. Materials that are washed away have to be deposited somewhere. The silt (delta) build-up at the mouths of rivers and streams is an example of the effects of deposition.

erosion – Water wears away materials that it washes. It picks up materials through the process of erosion, often causing severe damage; and deposits it at some other location, sometimes creating more damage when it is deposited.

evaporation – Water changes from liquid into gas through the process of evaporation. Evaporation causes a heat loss, which is used in evaporative coolers to cool homes.

humidity – Water suspended in the atmosphere is referred to as humidity. Dry air is usually considered more pleasant than moist (humid) air. Our bodies, however, function more efficiently when there is some moisture in the air.

hydroelectric – When water power is used to create electricity, the process is called hydroelectric.

irrigate – To irrigate means to supply with water. It usually implies moving water from one place to another.

precipitation – Rainfall. The process of converting moisture in the air (in a gaseous state) into water and depositing it on the earth (in a liquid state).

prior appropriation – The term refers to water rights. In Arizona, and in most of the Western United States, the law states that water rights belong to those who first put the water to beneficial use; i.e., to those who first appropriated the water.

riparian – Riparian rights to water are different from the right of prior appropriation. In places where the laws uphold riparian rights, the water would be owned—equally—by the owners of the stream (lake or river) bed.

salinity – Refers to the amount of chemical salts that are suspended in the water.

transpiration – The process of converting liquid water from plants and animals into vapor. It is similar to perspiration, except that in perspiration the body gives off liquid and in transpiration the body gives off water vapor.

watershed – A specific area where water is collected and ultimately drains to a particular water course or body of water.

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The following list of resource materials and sources is just a beginning but it should help you get started with your study of water. No effort has been made to recommend any one particular resource over any other; whether listed or otherwise.

NOTE: Please check the plant, soil, and other sections of this publication for ideas and sources of materials.

Contact your county agricultural agent for the excellent materials produced by The Cooperative Extension Service, University of Arizona, Tucson, Arizona.

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WILDLIFE



ARIZONA'S WILDLIFE – PAST, PRESENT, AND FUTURE

Introduction:

Arizona, with its widely varied landscapes, is blessed with an almost unequaled variety of wildlife—each species carefully adapted to live only in a very specific environment or habitat.

Kaibab squirrels live only in the coniferous forests of the Kaibab Plateau in northern Arizona. Wapiti, or elk, range the high north and eastern mountains. Pronghorn antelope race across the open plains and Kangaroo rats have adapted to the hottest desert valleys. Each creature has very specific environmental requirements.

Man is able to share the environments of all of these species. Wildlife species must adapt to the environment. We adapt by putting on or taking off clothing; piped-in water, trucked-in food; and electrical heat or cooling.

What is “wildlife”? What do we mean when we use this word? In this guide, “wildlife” will mean birds, fish, insects, mammals, reptiles, and amphibians—all living animals. All of these are a part of Arizona’s wildlife heritage; a treasure we must assure for all time.

For us to assure the presence of this great resource, we must know about wildlife, its environments or habitats. We must understand the *interrelationships* between species, between species and their environments, and the interrelationships between man and wildlife. And we must understand and practice the concept of *conservation*.

Wildlife conservation is the wise and careful use of a *renewable* resource. Conservation does not mean just “putting a fence” around a resource and giving it total protection.

The harvest of lumber from a forest, or of *forage* from a grassland, shows us that such a harvest, properly controlled, does not damage a living, renewable resource. Does this concept also apply to wildlife, which is also a living, renewable resource?

We know the values of wildlife to man, not just as food and fiber but as pollinators of domestic plants, as cleansers of the natural world, as sources of recreation, and as inspiration for songs and legend, art, literature, and dance.

History records conflict between man and wildlife: records of damage to man’s crops, of hereditary fears of certain species, and of wildlife occupying lands desired and needed by man to feed the evergrowing population. (How could America’s farmers have lived with a hundred-million buffalo?)

Our knowledge of, our attitudes, and our relationships with wildlife are many faceted. Our attitudes have been affected by history, by economics, religious and ethnic backgrounds, and today are being dramatically affected by a conflict between urban and rural understandings of our natural world.

There are many concepts and attitudes applying to wildlife, and perhaps as many questions. It becomes obvious that man has yet to fully understand our relationships with this natural world. But it is equally obvious that wildlife is, and has been, an essential and desirable part of our environment.

What was Arizona like when the European explorers and settlers came? What wildlife wonders did they see? Were the streams alive with fish and the hillsides covered with deer? Were there beaver in every river bottom and bighorns on every crag? The answers to these questions may surprise you.

There were beaver in most river and stream bottoms, in the Salt River where it flowed through what is now Phoenix, and in the Santa Cruz River, now downtown Tucson. Beaver brought some of the earliest explorers to our State when trappers came in search of furs.

There were more bighorns in early Arizona than now inhabit our State. There were no buffalo in Arizona—there are now.

But there are probably more coyotes in Arizona today than there were 200 years ago. There are none of the native elk, but perhaps more elk today than before. There are fewer bighorns and fewer beaver, but probably more mourning doves and whitewings. There are fewer Scaled and Montezuma quail, but probably more Gambel's quail. The once extinct Masked Bobwhite quail is being reintroduced. Pronghorn antelope, almost extinct in 1900, have increased to herds that now supply an annual harvest.

Some species of birds were more common; others have multiplied in number as a result of man's activities; and still others, such as the sparrow and starling, were introduced by these settlers.

Lewis and Clark, and other explorers, recorded times when they had to eat their horses and mules because wildlife was so scarce.

The answers to our questions are both yes and no. Wildlife was plentiful and wildlife was scarce. The answer varies with the species and the location.

Today's thriving species are those which have adjusted to living with man. This *adaptation* was usually forced by man's changes of the land. When the change favored a species, that species prospered. When the changes did not favor a species, that species adapted or passed out of the picture.

The coyote, perhaps the most adaptable animal in America, prospered with man's changes of the landscape (in spite of extensive efforts by this same man to eliminate the coyote). Today there are coyotes in nearly every state; in pioneer days there were none east of the Mississippi.

There have been many changes in this land and its condition since settlement began. These changes have had a dramatic impact upon our wildlife. Grasslands were overgrazed and when the grasses were replaced by less desirable plants, so also were the wildlife species changed and replaced. Forests were cut for their timber or to clear land for farming. Lush bottomlands were "corned" or "cottoned" to death and our grandfathers abandoned these lands and moved further west to start the process over again. An old farmer was once quoted as saying: "Young man, don't tell me how to farm; I've done wore out three farms."

This "rape" of America's lands was done in ignorance and in order to survive in a harsh new world. Our pioneer ancestors came and found a wilderness—and fought to survive. Can they really be blamed for shooting the grizzly bear who threatened their milk cow, their children, or their hog; or for shooting too many buffalo when the sale of hides and tongues

was a way to feed and clothe their families? We must recognize that the world then was different. There was a philosophy of endless resources and more than enough for everyone. Almost no one understood that resources are *finite* and that there could be a limit to resources used.

As man moved westward, he hacked out a living from the land. Part of his living was the meat and hides and feathers of wildlife. But much more important were the changes he made in the land. As dams were built and swamps drained, as grasslands became dry farms and then dust bowls, as rivers were channelized, wildlife was displaced or eliminated.

Today, Arizona is still witnessing a fantastic growth: massive construction projects, agricultural expansion, and increasing use of land for homes, industry, and recreation. Much of this has a dramatic effect on wildlife, far too often detrimental. But today, unlike in the past, there are knowledgeable, concerned people trying to alleviate and *mitigate* harm done to wildlife and its habitat.

One of the basic principles of wildlife conservation is that *wildlife is a product of its habitat*. Wildlife is a product of the land and the existing conditions on that land. This understanding can help us to benefit wildlife in the future.

Concern for wildlife began surprisingly early in America with laws restricting the harvest of deer in Massachusetts in 1718, and with laws protecting species from overhunting or overfishing. Long prior to American settlement, Ghengis Khan controlled the harvest of species. English kings set seasons and bag limits on deer, grouse, and salmon.

A major change that has benefited wildlife has been the creation of State Game and Fish Departments and Federal Wildlife Agencies. These agencies were charged with the care, protection, and management of the wildlife resource. This was perhaps the first far-reaching action taken towards the conservation of American wildlife. It put professional biologists and law enforcement people in a position to protect the resource and search for the ecological facts needed to perpetuate wildlife as a valuable national resource.

The history of these agencies is one of evolution, from a purely defensive or protective concept to complex management. Research, habitat protection, environmental study, education, and management have been added to protective action. The change has been from the politically appointed "game warden" to today's requirements for degrees in wildlife biology or ecology—where agencies commonly have Ph.D.'s on their staffs, and wildlife managers and law enforcement specialists are university trained.

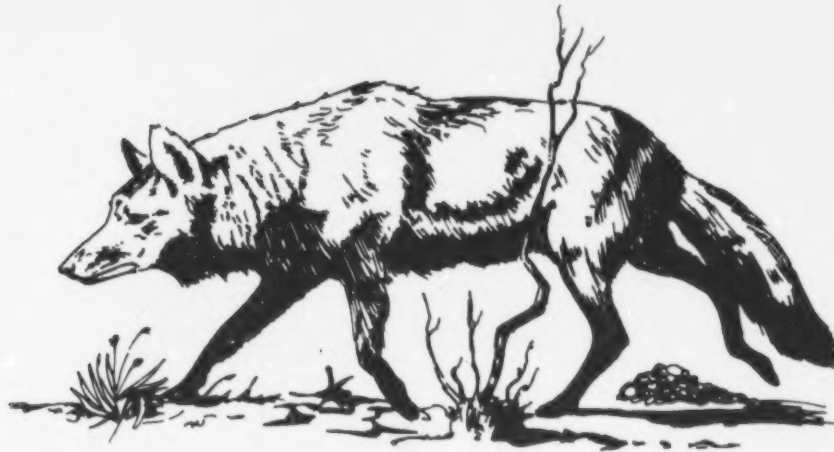
Looking into the future, it is difficult to foresee anything but a continued deterioration of our environment and, in particular, a loss of wildlife habitat. As our human population occupies more of the land and utilizes more of its resources, we leave less land, less water, and less plant resources for our wildlife neighbors.

We must understand that in the years to come there will be less wildlife than now exists. And we must understand why. We must understand that if this occurs it is because we have made the decision that these lands must accommodate man first, and wildlife second. Let us be sure that such decisions are carefully considered for alternatives. And let us never accept the loss of any species. In our environments there must always be room for at least a remnant of each.

We will never see the surging herds of buffalo our forefathers found on the central plains, but, somewhere, there must be room for herds of a size compatible to today's world. Surely, we cannot expect the thousands of deer, quail, and other species that are now a part of our environment; but we must make sure that there are always canyons and fencerows, forests and woodlots, deserts and marshes that we can spare for the preservation of this wildlife resource.

Arizona can be blessed with the wonder of wildlife—or it can be bleak, ugly, and minus this most precious resource. We could, perhaps, live without robins and squirrels or deer and black bears, but we cannot live without wildlife in its broadest context. It is up to us to make the future. The challenge is now—the responsibility is ours.

If we will learn, and teach well, the five basic concepts of wildlife conservation covered in this guide; if we understand and act upon them, there will always be a place for wildlife in our crowded and shrinking world.



BASIC CONCEPT NO. 1 – Wildlife is a product of its habitat

Here is a sample activity to use with the concept. Further activities can be found in the "action" section.

Suggested Activity – Mathematics

Some animals can tell temperature:

A cricket can tell you how warm it is. During warm weather his chirp is rapid and high-pitched. During cooler periods, his chirp slows. By using the following formula you can determine the temperature from the number of chirps per minute.

(N = Number of chirps per minute)

Tree cricket –

$$\text{Temperature} = 50 + \frac{N - 90}{4.7}$$



House cricket –

$$\text{Temperature} = 50 + \frac{N - 40}{4}$$

Katydid –

$$\text{Temperature} = 50 + \frac{N - 19}{3}$$



The problems can be reversed: The temperature is 78°. How many times per minute would each cricket chirp at this temperature?

OR: If it is 78°, which kind of cricket is chirping?

At times, cricket calling may not be readily available. Toy mechanical "clickers" such as those often found in Crackerjacks might be used to simulate the cricket's call.

What does this show about a cricket and his relationship to his environment? Is temperature a part of environment? When his chirping is slowed, are all his body functions reduced also? Would you expect to find crickets in polar regions? Why?

Be certain you check the temperature where the cricket is—not where you may be listening from.

Understandings:

A. Environment determines the kind of wildlife in a community.

The physical and climatic features of a given area—its elevation, rainfall, topography, *plant communities*, *microclimates*, the chemical constituents of the soil, the historic activity of fire, man's use or abuse, glacial or volcanic action—all of these things, and many more, help to determine the species and numbers of wildlife in a community.

A comprehensive description of an environment, here in Arizona or in any part of the world, will predict specific types of *resident wildlife*.

In an Arizona desert we might find a Kitfox; in a similar African desert area we would find a Bat-eared fox—a very similar animal. The grizzly bear, a former resident of Arizona, can be compared to the European brown bear; each lives in a very comparable habitat.

In each case, the comparative *ecological niche* is filled by a similar animal.

B. Each biome has a characteristic life.

The *biome* is the largest community unit which is convenient to recognize. In a given biome, the *climax* vegetation is the same; in the grassland biome, the climax vegetation is grass (perhaps varied species of grass in different areas of the biome, but grass as the dominant plant). In a *chaparral* biome, brush is dominant and in the coniferous forest, pines and firs are *dominant species*. The dominant plant reflects the major aspect of climate and largely determines the habitat for wildlife.

C. Every habitat has a set carrying capacity.

A unit of habitat has precise and limited capacities, just as a particular piece of farmland has its fenced boundaries and specific ability to produce.

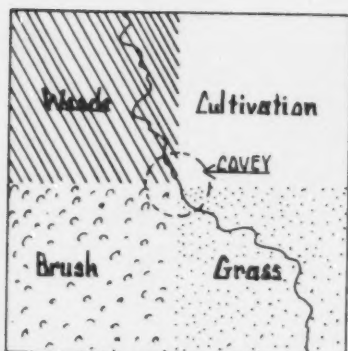
The farm can produce only so many bushels of corn, bales of cotton, or units of livestock, unless modified by seeding, fertilization, more water, *mulching*, etc. This potential remains fairly constant. And so it is with any unit of habitat. It can produce only so many horseflies, fence lizards, bobolinks, catfish, red foxes, or moose. Habitat is the key to the populations of any wildlife species. This habitat has a *carrying capacity* varying from day to day, season to season, but with precise limitations at any particular time.

D. The five essentials of wildlife habitat are: food, water, shelter or cover, space, and the arrangement of these elements in relation to each other.

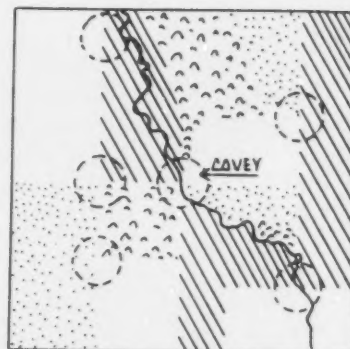
It is easy to understand that wildlife needs food, water, and shelter, but when we begin to define these simple words in relation to various species, it becomes very complex and fascinating. For example: Cover or shelter means not only cover to hide in, but cover to travel in, cover as shelter from the elements (one type for hot weather, another for cold), cover for stalking, cover for breeding, cover for *natal* activities, and cover for bedding.

Understanding the concept of food means a consideration of species, season, "good or bad" years, competitors, available shelter, and more.

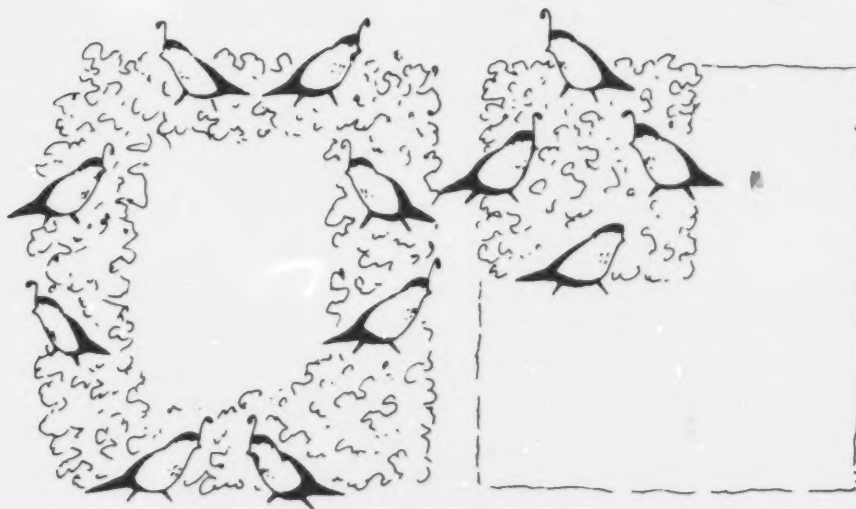
Look at these diagrams; they illustrate this point.



Poor edge-effect (1 covey)



Good edge-effect (6 coveys)



Distribution of food and cover is important. Ten acres of cover surrounding a field is more effective than a ten-acre square in one corner. This is sometimes called the concept of *edge effect*.

Water needs can vary from those of a Kangaroo rat, which uses no free water, to the needs of a fish which must live in water, travel in water, find food in water, shelter and reproduce in water.

Another wildlife requirement is space, or territory—again varying with species. A nesting wren may defend a territory of only a few hundred square feet; a mountain lion may claim a hundred and fifty square miles. A coyote will mark the boundaries of his territory just as we fence our property; a cardinal will vigorously evict another cardinal from his private kingdom, but will ignore a mockingbird in the same area. Territory is an important understanding when learning about wildlife.

Food, water, and shelter must also be properly arranged for the particular species of wildlife to make use of it. When the food is too far from the bedding shelter and the water is too far from escape cover, the habitat is not suitable for wildlife. Each species has its own measurement of these distances. The water hole that might be too far for a porcupine or a tree squirrel might not be too far for a mourning dove or an elk.

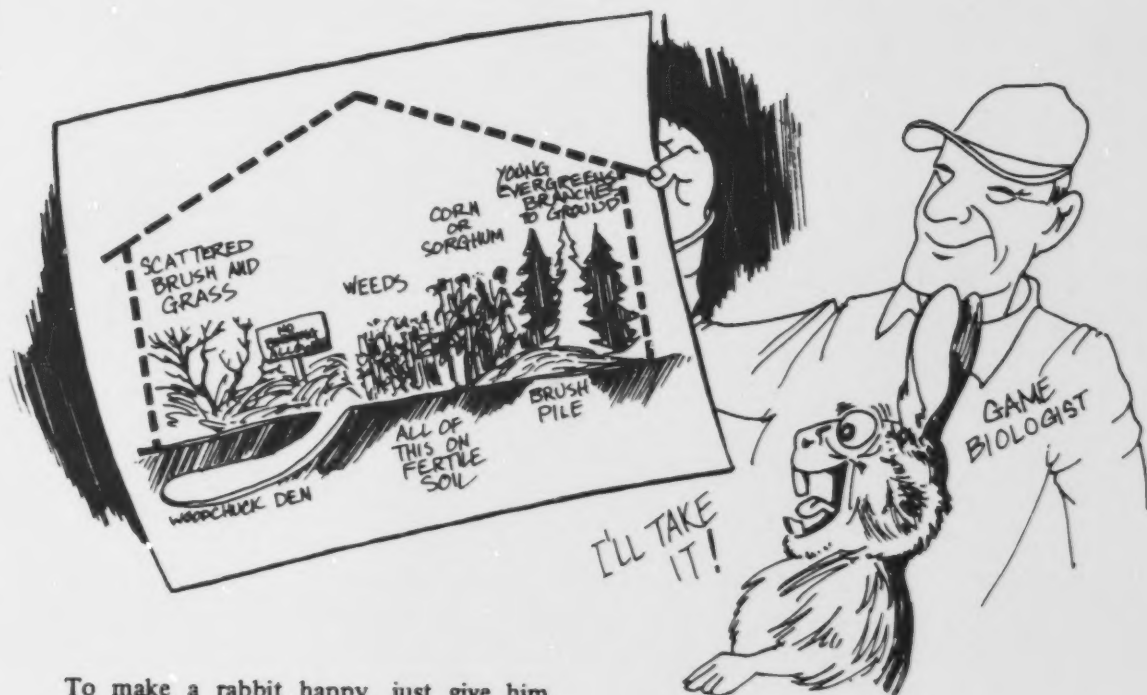
If, in your community, we moved all bathrooms to the farthest north edge of town, all bedrooms to the extreme south, all grocery stores to the next county to the east, and the water supply ten miles west, how many people would continue to live in your town? This is how it works for wildlife as well.

- E. In any environment, one component like water, air, light, or food may become a limiting factor. When these, or other resources, are in short supply, or in excess to the tolerances of an organism, they are said to be "*limiting factors*."

If a lake is so muddied by erosion on the surrounding watershed that sunlight can no longer penetrate the water, the microscopic plants (*primary producers*) which live in the lake cannot produce energy. Without this energy production, the food chain of aquatic insect-minnow-large fish is broken. The *limiting factor* of the large fish population then becomes the food supply, in this case the lack of minnows. But indirectly, the lack of sunlight was the limiting factor. Because of soil erosion there are no fish in the lake.

- F. Wildlife resources are limited in quantity, quality, and distribution.

Wildlife population levels are determined by quality and quantity of habitat. Some habitats have a higher "carrying capacity" than others and can support a higher density of animals. The extent of the habitat determines the distribution and "total numbers" of animals. For example: there is more pronghorn habitat in Wyoming than in Arizona and consequently a larger total population of pronghorns, even though "density" (pronghorn per square mile) might be as high or higher in Arizona.



To make a rabbit happy, just give him food, nesting cover, winter protection, and predator escape thickets. Happy rabbits mean more rabbits.

- G. Regulations, although desirable for good wildlife conservation, cannot substitute for good habitat, or save a species whose habitat has been depleted or destroyed.

There is no substitute for good wildlife habitat.

Laws and regulations protecting wildlife are important and desirable, but will not produce wildlife. A refuge is of no value unless it contains the five basic elements of habitat needed by the species to be protected.

The reduction or loss of a population is more quickly and completely done by habitat destruction than by any combination of hunting, poaching, trapping, or even deliberate vandalism. A species can only be preserved and made to prosper by preservation and improvement of habitat.



**GOOD HABITAT
PRODUCES A
WILDLIFE ABUNDANCE . . .**



**WE CAN REBUILD
WILDLIFE HABITAT!**

BASIC CONCEPT NO. 2 – Wildlife species are interdependent with one another and with their environments.

Here is a sample activity to use with the concept.

Suggested Activities: Science, Social Studies, Music

The Food Chain Game – The Web of Life

A game which demonstrates interdependence between living organisms and their environments.

Equipment needed: a large ball of string or colored yarn and a small sign for each participant (see illustration).

Procedure:

Make a sign for each student. The signs can be simply lettered or a project for your art class.

Each sign should represent some element of the environment. Start off by using the immediate neighborhood. Suggested signs could be: sun, water, air, soil, native plants (grasses, trees, bushes). Now add man's plants such as corn, wheat, apple trees; native animals (herbivores, carnivores, omnivores, decomposers). Add domestic animals. Make the list fit your community.

Seat the students in a tight circle; give each student his sign. Using an inquiry technique, start the flow of energy from the sun: Where does it go and how? When the web is complete, talk about what happens to the web when something happens to any unit. Add in your own problems: a forest fire, flood, drainage project, etc.

Try the Web of Life in Social Studies by substituting elements of the man-made community: a church, service station, bank, lumber mill, grocery store. What are the relationships and interrelationships? Use the Web of Music. Have your students portray instruments in an orchestra. How does each instrument relate to the final sound?

Try different *ecosystems*: desert, forest, polar ice, African *veldt*. There is almost no end to the teaching capacity of this game.

Understandings:

A. Living things interchange energy and matter with the environment and with each other.

The essence of life begins with light from the sun, and it is continued by the transference of this energy from sun to plant to animal.

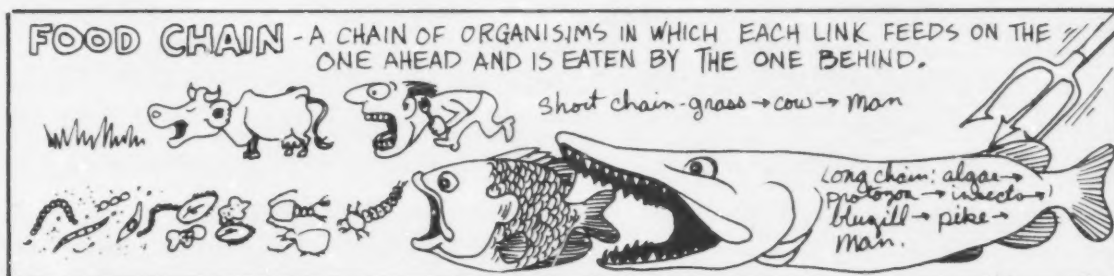
This connecting of energy (organism to organism) is called a "food chain." Each organism has its own very specific food chain which may overlap that of some other organisms. The interlocking pattern of these food chains is sometimes called the "food web" or the "web of life." Through this fantastically complex web flows energy and matter, circulating from organism to organism and from organism to environment.

- B. The comprehension of food chains and food webs is basic to understanding wildlife conservation and management.

An elementary knowledge of wildlife is that animals must eat, and that their food must be of a proper quality and quantity. Each living thing, from microorganism to Scouts, has a specific food chain to supply this need.

The food chain illustrated here shows only one part of the food chain of the fisherman. Remove the fisherman from the scene and it becomes the food chain of the pike. Remove the pike and what remains is the food chain of the bluegill.

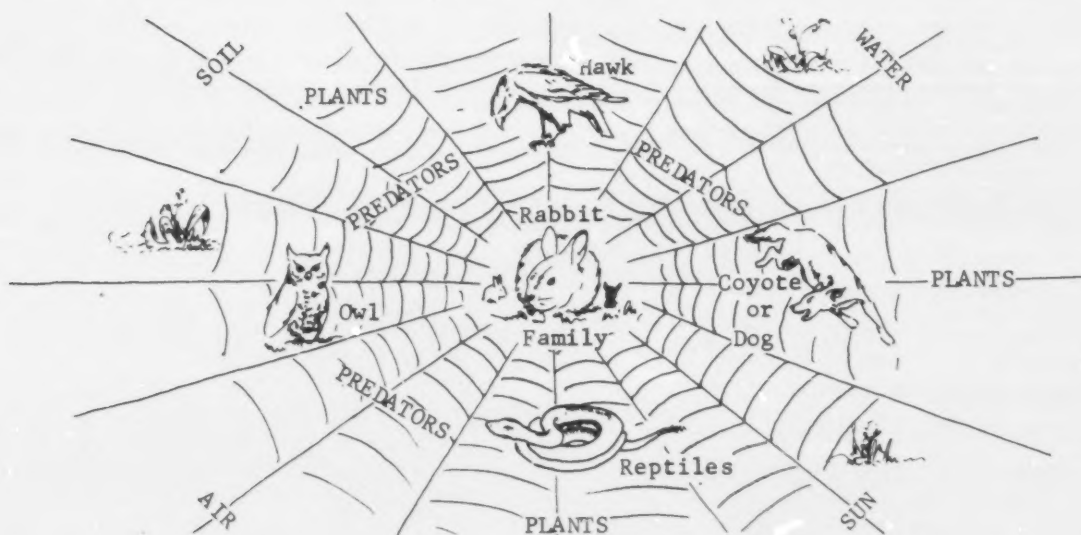
The complexities and interactions of food chains must be understood if we are to manage and conserve wildlife. For example: a refuge cannot benefit a species unless it contains the food chain of that species.



- C. Living things are interrelated to each other as demonstrated by the food web of a given community.

We have learned that each living thing has a food chain. Now we learn that these food chains overlap and interconnect; that the cottontail is eaten not only by the coyote, but by the owl, the snake, the bobcat, the hawk, and others. The flying insect may be part of a food chain for a skink or a skunk, a snake or a raccoon, a trout or a sparrow hawk. Grass may be eaten by rodents, birds, or buffalo.

WEB OF LIFE



- D. All wildlife have individual, specific living requirements yet are interdependent with their environments.

Each species of wildlife (earthworm, eagle, chipmunk, salamander, or elk) have specific needs, specific living requirements. The soil must have a specific moisture content for the earthworm; specific conditions must exist for the eagle to build her nest; ground cover must be available for the chipmunk's scurryings; a transitional availability from water to land and return are necessary to the salamander; and the proud Wapiti loves a muddy wallow during fly time. Unless the specific needs are satisfied, these creatures would not be present. These are only some of their involvements with their environment.

In turn, the earthworm may help to *aerate* the soil of the mountain meadow; the elks' droppings stimulate the growth of grasses (grasses which hold moisture in the soil) and supply food for the elk and other wildlife. Grass seeds provide food for the rodent or wild turkey, which may be eaten by the eagle. So, the earthworm affects the elk and the elk the eagle. All nature shows these fascinating patterns.

- E. Certain natural processes, generally occurring as cycles (hydrogen, nitrogen, carbon, water), influence the interrelationships of living things and have effect on the physical world.

Both plants and deer receive water from, and lose water to, the atmosphere. A deer may obtain some needed moisture from its plant food, and its body discharges of moisture may be used by another plant.

These interrelationships between a deer and its food are only details in the natural water cycle, and this is just one relationship effected by one natural process or cycle. At another stage of the cycle, water may erode a hillside, uproot and destroy plants, and even drown the deer.

- F. Living things respond to their environment.

All living things respond in a positive or negative way to their environment. When an environment shows increased value (with reference to this single living thing), the organism responds by increasing growth, life span, health, or most commonly, by increased reproduction. In a deteriorating environment, the organism shows stress, starvation, and a reduced reproductive potential.

On a good browse range, a mature mule deer doe will normally produce two fawns, and these fawns will have a good chance of survival. On a poor or overgrazed range, this doe may give birth to only a single fawn whose chances of reaching maturity are slim.

Food is, of course, only a part of this environment and a parallel reaction will be seen when other parts of the environment are involved. Environmental quality may be seasonal; thus a drought, hard winter, or a range fire will produce a response in health or reproduction.

G. Wildlife resources are vulnerable to depletion in quantity and quality. They vary in susceptibility to this depletion.

Some wildlife species are more easily damaged than others. Those species which are very specific in food needs can be decimated by the loss of, or damage to, a food supply. Fish-eating birds are an example: when water is polluted, fish die and water birds starve or migrate. If fish have too much pesticide deposited in their fatty tissues, the birds' eggs may not hatch. Either way, the water bird population is reduced.

Coyotes, for an opposite example, are opportunists. They can and will eat carrion, rodents, deer, insects, or fruit, depending upon availability, and if all else fails, will raid your garbage can or eat your cat. A coyote population is not very vulnerable to depletion.

H. Species and environmental factors interact to keep animal populations in balance with the community.

Some wildlife species compete with others for food, space, water, or other needs. Some wildlife species are neutral in their effects upon each other; still others are mutually beneficial, or one may benefit another without harm or help to itself. Some species are *parasitic* upon another, some are *predaceous*. (The predator kills for food; the parasite lives upon the host, usually without killing.)

Each of these relationships have important effects upon one or both of the species.

A whitetailed deer and a wild turkey may compete for autumn acorns, and a badger may dig for the same rodents that the bobcat stalks by moonlight. A zebra-tailed lizard and a Gila monster may have a completely neutral relationship.

The prairie dog supplies food for the black-footed ferret, and yet, without the ferret to help control his numbers, the prairie dog might soon overpopulate his towns and rampant disease could decimate his population. So the prairie dog and the ferret are mutually beneficial.

A smart coyote may follow the lumbering badger and watch his laborious digging for rodents and catch those rodents that escape the badger's grasp. So the coyote benefits from the badger's efforts. The badger is not harmed or helped by the relationship.

Environmental factors such as water, light, moisture, and temperature, working together, also affect and control wildlife in complex ways. The desert Spadefoot toad reappears for his nuptial ceremonies and reproduces his kind only with the summer rains. Temperature controls the hatching of the brook trout or leopard frog egg, temperature and moisture working together create the humidity necessary for a quail egg to hatch, and the lengthening hours of daylight trigger the nesting of the wild turkey in spring.

This wondrous chain of reactions to environmental factors, and to other species, constitutes an endless and fascinating study.

- I. The addition or removal of a species from a community may create harmful or beneficial reactions within the environment of a species.

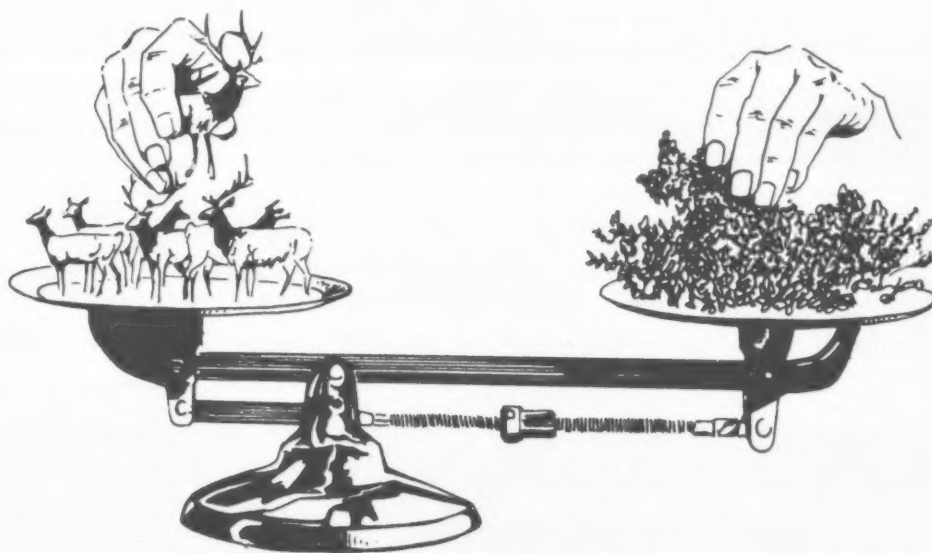
Quitobaquito is a desert stock pond fed by a spring on the Organ Pipe Cactus National Monument in Arizona. This small body of water contains a remnant population of a tiny one-inch fish called the desert pupfish. This is the only known population of this particular fish in Arizona, and perhaps anywhere. Recently, someone introduced another small fish, the western goldenshiner, to these waters. The shiner is larger, a more active competitor for food, cover, and space, and might well supplant the *endangered* pupfish by simply crowding it out.

Quitobaquito had to be drained and treated to remove the threatening shiners in order to preserve the endangered species. The addition of an *exotic* species had endangered the native species.

Some lakes have excellent *plankton* growth and good aquatic insect life, but the next step up the food chain (which is minnows) is inadequate. There are no small native fishes to fill this niche in the food chain.

Fisheries biologists (after careful investigation and evaluation) sometimes introduce a small fish such as the threadfin shad to these lakes. The shad is a small silvery fish which is very prolific and seldom gets more than four or five inches in length. The idea is to complete the food chain of the black bass, a species much desired by fishermen. Bass, with this addition to the food chain, increase growth tremendously. Year-old bass averaging about three-quarters of a pound before the introduction of shad to the lake now have nearly doubled that weight.

The addition of a species to the community in this case has helped the native fish. The introduction of *exotic* organisms to a community thus may be either beneficial or detrimental.



BASIC CONCEPT NO. 3 — Wildlife populations and their environments are not static but are in constant change.

Here is a sample activity to use with this concept.

Suggested Activity — Science

Make a Bird Calendar

Use drawings or cut-out pictures of birds to indicate dates when the birds were seen.

Gather your data and make drawings over a full year. Then add to your calendar year after year. Discuss where and why each bird was seen. Was the bird migrating? Had the bird come to that spot for a particular food or for water? Would that food or water be available only at certain times of the year? Are changes of habitat responsible for its presence? Are these habitat changes seasonal?

Make a scrapbook of birds seen and identified by the class.

Understandings:

- A. Succession is the gradual and continuous replacement of one kind of plant or animal by another, and is characterized by gradual changes in species composition.**

When plant succession begins in a burned-over forest, plant replaces plant (grasses and weeds to brush, to aspen, to pine or fir) depending upon location. As plant succession occurs, there is a parallel succession of animal life—mice and gophers to deer, to squirrel. Insects and birds are a part of the pattern—grasshoppers and horned larks in the grass; certain beetles and bush tits in the brushlands; tent caterpillars and woodpeckers in the birches; and bark beetles and jays in the *climax* forest.

These are simple examples. The presence of each of these animal species also helps establish a habitat for a predatory species which depends upon them, in part, for their livelihood.

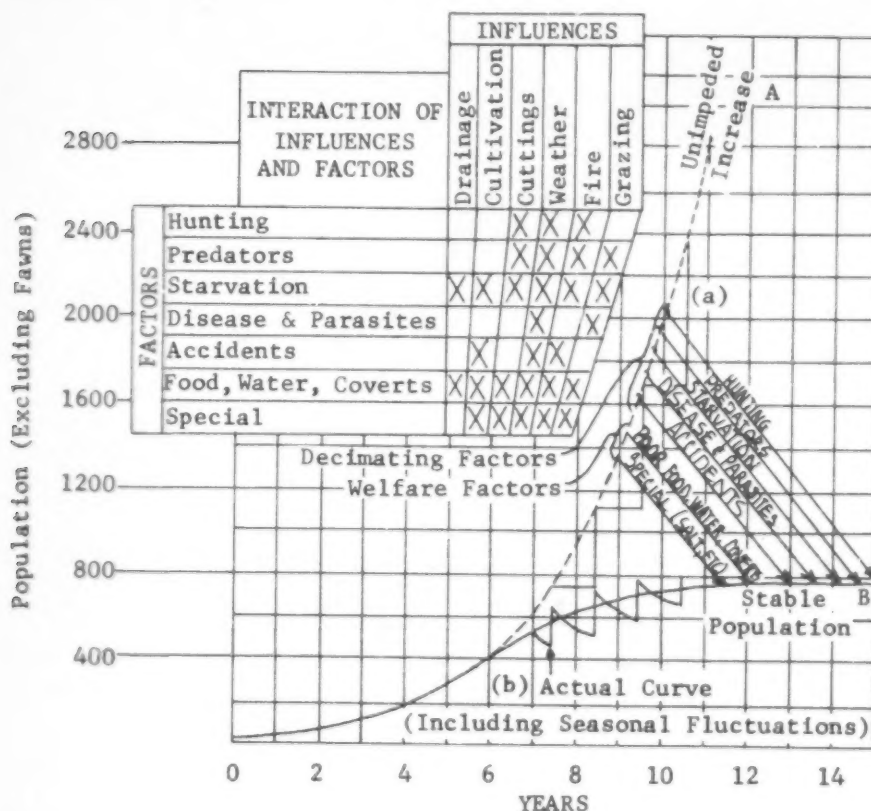
- B. Changing environment affects living things. The more specialized an organism becomes, the less adaptable it is and the less able to survive environmental change.**

Environmental changes, from whatever cause, have dramatic effects upon all living things. Some are affected more severely than others. Natural changes in environments are often so gradual that species have time to make adaptations; man-made environmental changes are so rapid that there is no time for adaptation.

The Avra Valley of southern Arizona, once the home of the Masked Bobwhite quail, was badly overgrazed in the late 1800's and early 1900's. The bobwhite became extinct in our State. This beautiful quail could not adapt to a dramatic change in its environment.

- C. Given sufficient natural resources, a population will continue to increase in size until some limiting factor is imposed.

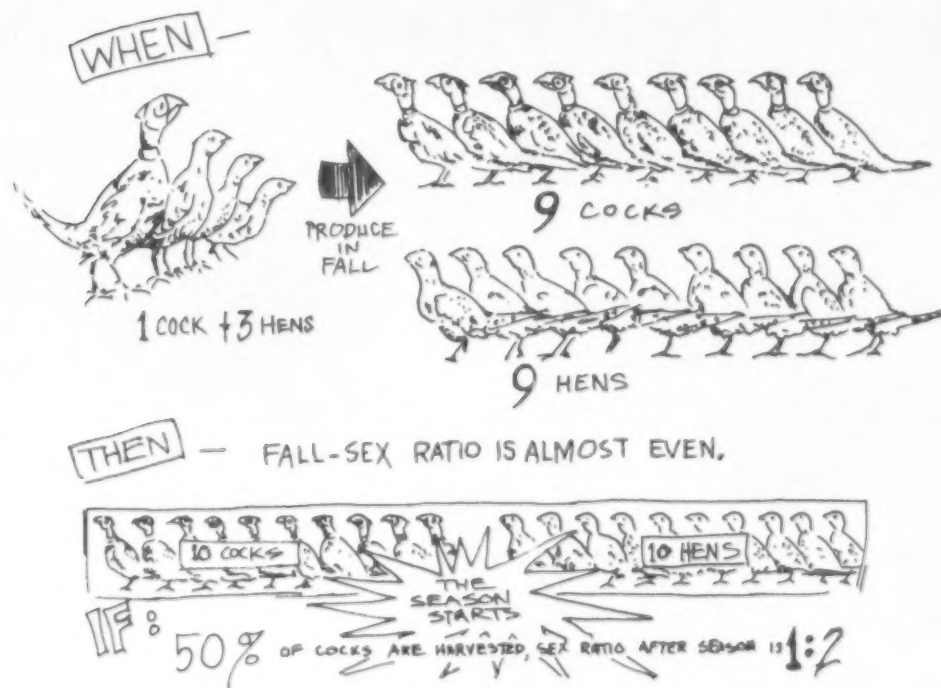
If a pair of quail in excellent habitat raise a dozen young a year, it would not be long until we would be knee deep in quail. But we are not up to our kneecaps in quail because factors other than the supply of food, water, cover, and space are also involved. Such things as accidents, disease, and predation keep this quail population from bursting its seams. The excellence of the habitat and the reproductive potential of the birds tend to increase the population, but the effects of accidents, disease, predation (hunting is a part of this predation) exerts a downward pull and prevents the population from reaching its theoretical maximum. Many species also reach a "saturation point" where social strife sets the ceiling they themselves will tolerate. So there is also a *social limit* to density. It is important to understand that no combination of factors ever occurs which enables a wildlife species actually to reach this maximum. The graph shows these factors at work on a deer population.



D. Living things tend to produce more of themselves than their habitat can support.

The reproductive capacity of wildlife is completely astonishing. The fact that one pair of quail, if entirely unmolested in an "ideal" environment, could become 1,024 quail in three years, or that a pair of pronghorn antelope, in spite of breeding only once a year and averaging less than two fawns, could increase to ten antelope by the end of the third year, is rather startling. A mature female black bass may lay over 20,000 eggs in one year. A mourning dove may lay only two eggs per nesting, but may nest three times in a summer breeding period. The reproductive potential of insects is legendary.

"If excess animals are not taken . . . nature will pare them down to fit . . . the habitat."



The potential production of organisms would soon inundate the habitat—the lake would overflow with bass and the southern desert grasslands would swarm with quail. In the great scheme of things, this mass production must be matched by numerous factors which tend to repress increase.

Creatures which are heavily preyed upon, like the cottontail rabbit, are more prolific than others. *Prey species* have high breeding potentials, which presupposes some natural means to dispose of the surplus.

Factors of predation, starvation, disease, accident, a reduced quality of food, habitat destruction, and the encroachment of civilization all extract a heavy toll from this production. The need of an animal to control a given amount of territory, to "own" a homesite, can limit a population. If and when one or more of these factors is partially

nullified, a population increase can be expected, to be followed sooner or later by a larger mortality which tilts the balance in the opposite direction.

BASIC CONCEPT NO. 4 – Wildlife is a renewable resource.

Here is a sample activity to use with this concept.

Suggested Activity – Mathematics

Ten million ducks are nesting in central Canada. They begin their winter migration to the South. Twenty percent go via the Pacific *Flyway*, twenty-five percent via the Atlantic Flyway, forty-five percent go down the Mississippi Flyway and ten percent are scattered. How many follow each flyway?

One-third of those using the flyway in which your State lies go through your State. How many ducks migrate through your State?

Of the ducks passing through your State, one percent are harvested by hunters. How many ducks are harvested? Is the hunter harvest endangering the duck resource?

Understandings:

A. Wildlife is considered to be a public resource.

Wildlife, by law, is the property of the "State" which, of course, means that it belongs to the people. This originated with the constitution and "states' rights" where states were given jurisdiction over wildlife, except for migratory species such as waterfowl. Migratory birds are regulated by treaties with Canada and Mexico. Even here the State has control within boundaries set up by the treaty. The state can be more restrictive than the treaty, but not less restrictive.

Wildlife was made the property of the "several states" in contrast to the laws of Europe where wildlife was the property of the rulers, and common people could not hunt or fish.

B. Wildlife is not immortal and cannot be stockpiled—nor are all wildlife resources equally abundant.

Most species have relatively short life spans and a tremendous potential to reproduce. A rule of thumb could be "the larger the animal, the longer the life span and the smaller the reproductive capacity; the smaller the animal, the shorter the life span and the greater the reproductive ability."

In smaller animals there is an annual cycle of increase and loss which we call the "annual turnover." In birds, like quail, this population may increase 250 percent during spring and summer, and decrease to the original numbers by the end of the following winter. January may show a population of 300 birds, July 1000 birds, and the following January 300 again. A high production rate always indicates a high mortality.

These wildlife resources are based upon the quantity and quality of habitat for that specific species. Thus we may have fantastic populations of katydids or blackbirds, but not necessarily equal populations of salamanders or sea cows.

C. A renewable resource can be managed to extend its values, and the harvest of some species of wildlife can be an important tool of this management.

In the harvest of timber on a well-managed forest, trees are cut and made into lumber, paper, and other products. New trees are replanted or are helped to reforest the area—to be harvested at some future time.

This same concept of management is true of the wildlife resource. Wildlife is renewable and can be used without destruction or damage to the resource.

Large *herbivores* (deer, elk, moose, etc.) have the capacity to destroy their own habitat when populations increase beyond the carrying capacity of the range. Man, having removed the grizzly, the wolf, and reduced cougar numbers, must now take the place of these predators and remove an annual surplus in order to prevent this destruction. Animal numbers can increase rapidly on a good habitat, but the habitat, once damaged, is slow to recover.

Small game, such as quail and rabbits, have a tremendous reproductive potential and an equally large annual mortality. Man can well afford to harvest a share of this annual mortality rather than letting disease, starvation, accidents, etc. take their toll. Again, man inserts himself into the scheme of things and takes a share.

It is necessary to harvest big game in order to protect habitat, but it is also desirable because of man's benefits from the harvest. With smaller game, the harvest is not necessary, but is desirable and is a valuable resource. Equally important, monies from hunting fees pay the game management and protection costs for all wildlife species, even the unhunted species.

Harvesting does no more than utilize a part of the annual surplus—a surplus that will not survive the winter, whether hunted or not.

D. Nonconsumptive use of our wildlife resource is advocated by some groups.

There are people who object to the killing of any animal. They oppose hunting as an element of wildlife resource management. Their objections are philosophical; they feel that because man no longer needs to hunt for food, he should not hunt. This philosophy objects to the harvest of wildlife for "sport" or recreation.

Some accept harvest as a necessity of good wildlife conservation, but feel that such harvest should be by professional wildlife managers, not by hunters.



- E. Certain public agencies are charged with the responsibility of wisely managing the wildlife resource and that management is mostly paid for by fees obtained from the harvest.

The protection and management of wildlife in Arizona is the responsibility of the State Game and Fish Departments and the United States Fish and Wildlife Service.

In most states, all monies to manage, protect, conserve, or benefit wildlife come directly from the hunter and the fisherman. His licenses, his taxes on sporting goods, and the fines he pays when he breaks game laws, pay for the research into wildlife ecology and new management techniques, protection of all wildlife (not just the hunted or fished for species), preservation, reclamation, and improvement of habitat, wildlife conservation education, and reintroduction of species—in short, all wildlife conservation work accomplished.

Usually, we consider that there are five basic steps to this wildlife management. These are:

Inventory — an understanding of what species are in the land unit being considered and why they are there (habitat evaluation).

Census — some determination of numbers in the population (how many eagles are there?)

Yield determination — how much is produced, what is the productive capacity of the area for each species?

Diagnosis or interpretation of these factors — a careful evaluation of the resource and its potential.

Controls and manipulation of the resource — this could be total protection for an endangered species, very limited harvest on a small population, or an intensive reduction of a herd that threatens its own habitat. Control and manipulation would also include activities to improve habitat for species.

These are the basic concepts, but wildlife management is much more complex than these simple statements.

BASIC CONCEPT NO. 5 – Man is, and has been, an important factor affecting plant and animal succession and environmental processes.

Here is a sample activity to use with the concept.

Suggested Activity – Science

Pollution and Fish

Using gallon jars for aquariums and whatever easily-obtained fish are available, fill each jar with clean water (if chlorinated, allow to set overnight). Add a small aquatic plant, using clean sand to anchor the plant.

Use as many jars as possible so as to allow the widest scope of alternatives. Place one fish in each jar. Minnows can be obtained reasonably from fishing bait dealers. Guppies are also common and easily obtained.

Now introduce various pollutants to your little "ecosystems." A great variety of materials can be considered: natural pollutants such as soil or ash (as from a forest fire), and of course, many of man's pollutants such as herbicides, pesticides, oil, detergents, soap, sewage, etc. Many items can be introduced by using a "dip stick"—a piece of cardboard lightly sprayed or painted with the pollutant material. Immerse the stick in the water for only a few seconds. Various materials can be used individually or in concert. Varied amounts may also be introduced.

The important feature of this activity is of course the extensive recordings made of the experiment: How much? How long? What effects? What species? Different effects on other species, etc.? Be sure to keep one jar uncontaminated as a control.

Understandings:

A. Increasing human populations and technologies require space and activities often inimical to wildlife.

We are all familiar with the predictions for human populations and have seen and felt the dramatic increases all over Arizona. But most of us have not recognized the tremendous effect this has on wildlife through the destruction, alteration, and division of wildlife habitat.

The greatest threat to wildlife, not only in Arizona but worldwide, is man's activity in development. When a city expands, when a highway is built, when forests are logged, when livestock is grazed, when crops replace virgin land, wildlife is vitally affected.

A freeway occupies only 20-30 acres of land per mile, but more important than the acreage is the division of that piece of land. This may separate the water from the food or shelter for a species, and so may eliminate the entire square mile as usable habitat for that particular species. Look back at the diagram in Concept No. 1 D. Imagine a highway superimposed diagonally across this map. What would this do to the quail in the area?

Impose other activities on the diagram; the results are much the same—wildlife habitat is eliminated.

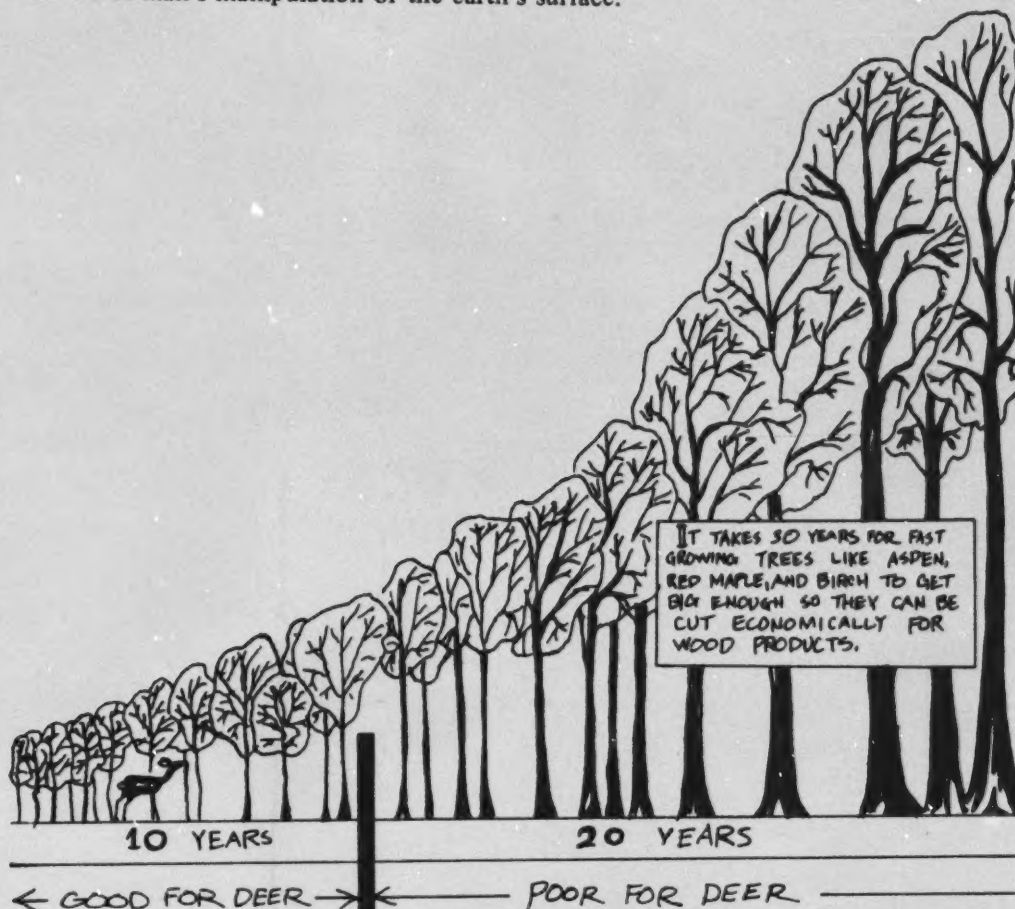
Much of what modern man does in his struggle for “progress” is detrimental to wildlife. If man cares enough, some compensation can be made, some mitigation for habitat and species damage.

This we must learn to do or wildlife will continue to lose.

B. The use made of one resource will affect another adversely or beneficially.

The use of one resource may have important effects upon another resource. These effects can range from highly beneficial to seriously detrimental, but there is an effect.

When a forest is logged, an *understory* of grass and *forbs*, bushy plants, and young trees begin to vegetate the opened areas. This change of habitat may be highly beneficial to deer (on a short-term basis), but if we look at the needs of Lewis woodpeckers or Abert squirrels, the habitat for them has been damaged or eliminated by this logging activity. This is only one simple example, but it illustrates conflicting effects of man's manipulation of the earth's surface.



C. Wildlife populations are decreased by many of man's activities.

Almost everything man does has an effect upon some species of wildlife. The effect may be beneficial or detrimental, but too often it is the latter. Some of this harm to wildlife is because man does not care, but most of it is unthinking and unknowing.

The important thing to understand is that all of this loss is not necessary. Damages can be mitigated and alternatives can be taken which are less harmful to wildlife. We abuse our land in many ways—strip and open-pit mining, overgrazing, careless road construction, poor farming techniques, misplaced housing projects—the list is endless. But it is not necessary to damage our environment to this degree.

When a highway is built, it is commonly built the shortest, most economical way. Many times this unnecessarily destroys wildlife habitat. There is more than the shortness of the road and the economy of the moment to be considered. Today's savings of dollars may be tomorrow's loss of a valued resource.

When man farms, he must protect his crop against depredation from insects, so he applies pesticides which damage nearly every animal organism they contact. Different techniques of farming can help alleviate this problem and reduce the need for pesticides. Other chemicals can be developed that are less dangerous to the environment, and natural controls can be sought.

In Europe, coal is strip-mined, but with careful attention to returning the land to its ability to produce other values when the mining is completed. Overgrazing can be prevented by carefully balancing livestock (and wildlife) numbers against the plant productivity of the range. Roads and highways can be designed to have a less disruptive effect upon the countryside. Poor farming techniques can be improved and subdivisions can be placed on lesser value lands.

Some of these things will cost you and me a little more money, but it will give us, our grandchildren, and wildlife a better environment. We cannot afford not to pay these increased costs.

D. Depletion of a wildlife resource can be slowed or halted by protection of habitat, by providing new habitat, or the improvement of existing habitat. The development and adoption of alternatives in habitat use is also most important.

The basic key to greater wildlife numbers is the protection of habitat, the improvement of existing habitat, or the creation of new habitat. Improvements might be: reseeded, development of water sources, manipulation of plant species, reduction of competition (*feral* burros or livestock), control of disease, establishment of refuges for endangered species and resting areas for migrating birds. Predator control, a controlled harvest, changing land-use patterns, alternatives to total clearing, rechannelization of waterways, freeways, certain pesticides, herbicides, and fertilizers all can aid wildlife.

E. Man has at his disposal tools and knowledge to change his environment for better or for worse. Wildlife is the end product of his wise use of the land and water resources.

While there is still much we do not know about our natural environment, and the interrelationships within it, there is much we do understand. We know and understand

enough to be able to substantially reduce the habitat and environmental destruction we are doing and have already done. And we know enough to prevent or mitigate much future damage.

Man has produced the tools of destruction: the bulldozer, the dragline, the dredge, and these same tools can be the tools of reclamation and repair. Tools that can drain a marsh or level a mountain can create a lake, or reclaim a strip-mined landscape.

The combination of man's increasing knowledge and his capacity to manipulate the physical world around him allows him to change his environment almost as he pleases. He must accept the risk of such activities and must recognize that these actions must be limited and controlled by understandings of their possible consequences. Every act of man which can react upon his environment must be evaluated and accepted or rejected only after careful consideration of these consequences.

- F. Wildlife has many values to man and is a most valuable American resource. Man cannot live without wildlife.

Man's relationships to wildlife have changed over the centuries, but not his dependency upon their values. A deer or a beaver was once an important addition to his way of life; now they contribute food and fiber as a secondary importance. Recreation has become the major reason for hunting and fishing, although wildlife as a food is still cherished. Man's dependency upon wildlife has not changed. He still needs the spiders' control of insects, the pollinating activities of butterflies and bees, the rodent control work of the bullsnake, the seed scattering of birds, and perhaps even the rooting of the Collared peccary, disturbing the earth and allowing percolation of scarce rain and assisting the generation of seeds. The earthworm, the dung beetle, the woodpecker, and the carpenter ant all play important parts in man's environment.

Mankind is inspired by the color, grace, and uniqueness of wildlife.

- G. Adequate wildlife conservation practices depend upon a knowledge and appreciation of natural laws and the application of knowledge from many disciplines. These practices also require long-range planning.

Management of wildlife requires an intimate knowledge of the life history of the animal. It is necessary to understand population dynamics, the ecology of the area, the relationships of species as well as the plant life, its productivity and potential. These knowledges come from study in many disciplines and from practical experience in the field.



All of this and much more, combined with careful, long-range planning, is needed to achieve proper and careful management of the wildlife resource.

- H. **Man has a moral responsibility for his environmental decisions. The responsibility for preservation of the environment lies with the individual, the community, the state, and the nation.**

Man, being the only animal capable of completely destroying the environment for himself and other organisms, and being also the only animal capable of mitigating this damage or repairing it, has a moral responsibility to reduce his impact upon the world in which he lives.

An important part of this complex problem is man's exploding population. Just a century ago there was still room for all, sufficient resources for man's needs, and plenty of space and resources left for wildlife. Today, man's increasing demands for resources severely reduce wildlife habitat, depriving animals of food, water, and shelter, and have cast a blanket of pollution over the earth. All this makes it increasingly difficult for wildlife to prosper, or even to survive. A major understanding should be that man must consider the reduction of his own numbers and life style to comply with the limits of his existing habitat. A quality way of life can only be achieved on an understocked habitat.

A land ethic must become a part of each person's way of life. We must learn to realize that land, and all that lives upon it or acts upon it, is not ours to own—to use and abuse as we see fit. Each of us must recognize that he is only in stewardship of these resources. They are only ours temporarily—to use and care for and pass on undiminished in quantity and quality. As we make this an individual way of life, it will become goal, policy, and law for community, state, and nation.



SUGGESTIONS AND ACTIVITIES

Art

A. MAKE A BIRD TREE

Bring in a dried branch (a nice piece of manzanita is especially good); choose an interesting one, of good size. The branch can be hung on the wall or "planted" in a container. Have children draw, or cut out, birds to hang on the tree. Bird pictures should be mounted on heavier paper to make them hang well. Birdhouses can also be added, perhaps three-dimensional ones. Birds could also be modeled from styrofoam and covered with colored tissue. Birds can be identified and reports written on their habitats and habits. Children can also build nests to go in the tree. (*Concept 1A*)

(Primary, Intermediate)

B. WHAT IS IT?

Collect large pictures of animals. Mount on light cardboard. Select the one feature for each animal that is special or is clearly an adaptation—webbed feet for a duck, antlers for a deer, "hands" of a raccoon. Place a piece of opaque paper over the animal and cut out a window which exposes the special feature. Have children try to identify animals from their special features. Talk about where the animal lives, how he is adapted for that place. Questions: What is it? Where does it live? How can you tell the kind of place it lives? What part is showing, etc.? (*Concepts 2D, 2F*)

(Intermediate)

C. WHAT ANIMAL EATS THIS?

Using crayon rubbings, spatter prints, or clay impressions, make a collection of images of various plants. Make a display of plants, which are foods for specific animals. Include the animal's picture in the display. Complete the display with drawings, photographs, or cut-out pictures of the animal's habitat. (See Arizona Game and Fish Department publications—"Arizona Wildlife" series.) (*Concept 2A*)

(Intermediate, Junior High, High School)

D. MAKE FISH PRINTS

Obtain several small, whole fish with scales, fins, and heads intact. Small fish such as bluegill or crappie are excellent. Keep the fish cold until ready for use. Gently wash and dry the fish but do not disturb the scales or fins. Spray the fish with hair spray. (You need work on only one side of each fish.)

Using acrylic paints and a wide, flat brush, stroke color over the fish—taking care to touch every part—including the fins. Wipe color off of the eye. Lift the fish carefully onto clean newspaper.

Lay a trial sheet of paper on top of the fish and hold in place with one hand. Press down gently, but firmly, on the paper with the other hand—head, body, tail, and fins. Try not to let your paper slip. Lift paper carefully to see how the print looks. If you used too much paint the print will be a blob. If too dry, the print will be faint. Use paper towels for trial printing. For finished products use rice paper or other soft papers. Cloth can also make an interesting hanging. (*Concept 1A, 1B*)

(Intermediate, Junior High)

E. ANIMAL TRACKS

Animal tracks are sometimes hard to obtain for the city school class. Here is a way track casts can be made without leaving the classroom:

Material:

- a. book on animal tracks (suggest *Peterson Guide to Animal Tracks* by Murie)
- b. 2 or 3 pounds of modeling clay
- c. several empty milk cartons (quart size)
- d. 10 pounds plaster of paris
- e. gallon can for mixing
- f. a shallow box (such as shirt box, approximately 10" x 16" x 2")

Flatten out clay in the shallow box. Fill the box approximately one inch deep and smooth surface. With a sharp pencil, very lightly draw track on surface of clay. (Can be life-size or whatever proportion you desire. Dog or cat tracks can also be used.) With fingers and blunt objects, impress the track into the clay.

Cut milk cartons horizontally into one-inch strips (forming approximately four-inch squares). Place one of these squares around the track and press gently into the clay.

Mix plaster of paris. Judge the amount of water needed to fill mold, then *add plaster to water*, not vice versa. Add slowly and stir until consistency of pancake batter. Pour into mold and allow to sit for 30 minutes or so. Carefully remove mold and cast. Allow to dry face up until hard. Paint as desired.

The clay can be reused again and again by washing off surplus plaster and rekneding. (*Concepts 1A, 1B*)

(Intermediate, Junior High)

F. FOOD CHAIN MOBILES

Create mobiles of food chains for various species of wildlife. Each class member can make one of a different species. The animals, plants, and other parts may be cut from magazines and posted on cardboard or they can be original artwork. Pieces of plant material, hides, bones, feathers could be included. Be sure that each mobile shows a food chain for a single animal. Or, one very large mobile might be made up with several animals (a mammal, bird, fish, etc.) showing these interrelationships. Color could be used to code this relationship. Would this be a food web? (*Concepts 2A, 2B, 2E*)

(Intermediate, Junior High)

G. PHOTO ETCHING

Good wildlife drawings or illustrations can be made from photo prints. Using a large 8 x 10 glossy print, you can make a very acceptable piece of artwork.

Materials: Photo, talcum powder, iodine, india ink, quill pens, a shallow tray, photographic hypo.

Sprinkle your photograph with talcum powder and with soft tissue rub over the surface to remove the gloss. Using the india ink and pens trace out the parts of the picture you want to work with. Using short lines and crosshatching, work in details and shade the drawing. Do not use large areas of solid black; break them up with lines or dots, etc.

Mix enough iodine and water to fill the tray about 1/2- to 3/4-inch deep. Enough iodine to make "weak tea" will suffice, but a stronger mix will work faster. Place your print in the solution, face up. Rock tray to wash photo. Do not touch the drawing area—it will smear. The photo will slowly disappear and the paper will turn bluish. When the photo image is completely gone, take the photo out of the solution and replace the solution with the "hypo."

The blue color will disappear, leaving only your drawing. Now wash your print for 30 minutes in clear water. Do not touch inked areas.

Allow your print to dry, face up, on absorbent paper towels. Your drawing is complete. (*No Concept*)
(Junior High, High School)

H. HOW BIG IS AN EAGLE?

Find out by making a set of eagle wings. Using the publication "Western Hawks," or field guides, make scale drawings of eagles in flight, with wings fully extended. Now take a single wing and enlarge it to life-size (see field guides for information). Trace your wing on a large piece of cardboard (large cardboard boxes). Have each student make a pair of wings. Design fastenings or handholds so that students can "wear" the wings. Wings may be painted realistically or feathers can be cut from heavy paper and glued on (again, see bird books). Have children wear the wings to understand the size of an eagle. (See following page.)

ALTERNATIVES:

Make a set of eagle wings as an American Indian dancer might. Use authentic designs. How about a record or tape of Indian music and learning to do an eagle dance? Could you perform the dance for other classes? What part did the eagle play in the lives of various tribes? (*Concept 5F*)
(Intermediate, Junior High)

WESTERN HAWKS— *What They Look Like in the Air*

BROAD-WINGED - RODENT HAWKS



AMERICAN ROUGH-LEG



SWAINSON'S HAWK



FERRUGINOUS ROUGH-LEG



WESTERN RED TAIL

MARSH HAWK



SHORT-WINGED BIRD HAWKS



GOSHAWK



COOPER'S HAWK



SHARP SHINNED HAWK

POINTED-WINGED FALCONS



DUCK HAWK



PRAIRIE FALCON

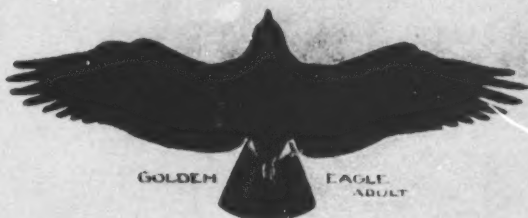


PIGEON HAWK



SPARROW HAWK

RING-TAILED - MOUNTAIN EAGLE

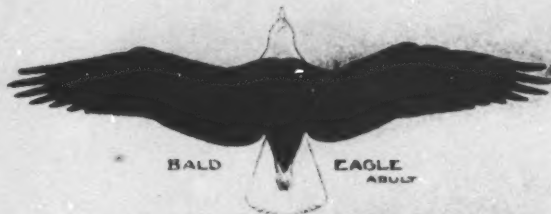


GOLDEN EAGLE ADULT



GOLDEN EAGLE YOUNG

WHITE-HEADED - FISH-EATING EAGLE



BALD EAGLE ADULT



BALD EAGLE YOUNG

WHITE-HEADED - FISHING HAWK



OSPREY

SMALL-HEADED - CARRION BIRD



TURKEY VULTURE

302

English

A. USING WILDLIFE IN ENGLISH: A Variety of Ways

1. Have students write a paragraph describing a species of wildlife, its habits, where it lives, what it eats, etc., but without naming the animal. Have other children try to identify the animal from the description. Do not describe the animal physically.
2. Have the children read about various animals (see Bibliography). Discuss life histories. Write poems or haiku using facts as well as fancy. Try cinquain and diamante.
3. Make a radio or television commercial about some aspect of wildlife. Choose an animal and tell about it. Present this to your class. Have children work as teams on television commercials.
4. Make a commercial for an unappealing type of wildlife (a vulture, snake, or skunk). Tape record or video tape your commercials. Play them back.
5. Have the children, individually or in teams, make a list—"To live I need..." Make the list as comprehensive as you can. Discuss how this list differs from the needs of any *other* animal. What are the differences, similarities? What items do you need that man makes? Could you possibly live without those? When your list has been reduced by these items, how does it compare with wildlife needs?
6. Write a letter to a friend telling about an animal you saw. Describe what the animal was doing, where the animal was—in the forest, desert, grassland.
7. Perform some drama. Write plays or skits about animals. Do role playing. Do pantomime. Try to be as realistic to the animal as possible. (*Concepts 1A, 1D, 2B*)
(Intermediate, Junior High)

B. WILDLIFE IN LITERATURE

Have students, as a group, name as many Arizona animals as possible (mammals, birds, reptiles, amphibians, insects). Place animal names on slips and have a drawing. Students are then assigned to research their animal and write a poem, essay, cinquain, etc., about it. Subject?—aesthetics, habits, habitat, characteristics—be innovative. Write a poem about a scorpion, an earthworm, a skunk, or a skink. An essay about the aesthetic values of a snake or a snipe. The characteristics of a bluegill or a chipmunk. (*Concepts 1A, 1D, 2B*)
(Junior High)

C. EXTINCT WILDLIFE

Write a news story about a wildlife species that has disappeared from Arizona. Tell why it vanished. Write a follow-up article about animals that are endangered in Arizona, and why they are endangered. Write letters to the editor expressing concern,

asking what can be done, telling what should be done. Tape record your own broadcast of news about an endangered species and what is being done to preserve it. (Be sure your animal is really endangered—the Arizona Game and Fish Department has a list.) (*Concepts 5A, 5C, 5D*)
(Junior High, High School)

D. BUFFALO

The Arizona Game and Fish Department has developed a simulation game, designed for high school students who have read, or are reading "Bless the Beasts and Children." The simulation covers a meeting of the Commission to determine the disposal of surplus buffalo from the two Arizona herds. Students role-play the parts of hunters, antihunters, range managers, members of conservation organizations, and others interested in the fate of the buffalo. They are forced to make a decision because the buffalo are overgrazing their range and must be removed. What should be done with them?

The simulation game is available free to high school teachers. (*Concept 1C, 1E*)
(High School)

E. BURRO – BURRO!

The Grand Canyon National Park has determined that there are too many "wild" burros in the park. Set up a simulation game based on the controversy aroused by the Park Service plans. Research the available information (check to see if your information is based on facts of burro ecology or on sentiment). Have children role-play the parts of park superintendent, park rangers and biologists, college professors, wildlife biologists, conservationists, and others involved in the controversy. (*Concept 1C, 1E*)
(High School)

F. LIBRARY

Have students choose books from the bibliography at the end of this section of the guide. Have them write reports on these wildlife books, or give oral reports before the class. Have the class discuss the report. What were the basic things learned about the animal? Did you already know some of this? Do you agree with the author's interpretation? Do you believe what you read? Discuss. (*Concept 1A, 1E*)
(Junior High, High School)

G. EAGLE–TURKEY DEBATE

Benjamin Franklin proposed that the wild turkey should be the national bird. Others supported the bald eagle. Have students read about both species and conduct a debate on this subject. Which bird should be our national emblem, and why? (*No Concept*)
(Junior High, High School)

Mathematics

A. BUILD A BIRD NEST

Have children build a bird nest, using only the materials a bird might use, and gathering the materials as a bird would—one wisp at a time, one pinch of mud at a time. Mud cannot be made, but must be found. Each item brought in must be worked into the nest. The nest must fit into the forks or branches of a tree (a dry, dead branch can be used and moved inside). Keep accurate records of the time (man-hours) that goes into the nest. Chart this and graph it. How many “birds” worked on the nest? How long would this nest have taken a pair of real birds? The idea is to document the work that goes into a nest. (*Concepts 1B, 1D, 1E*) (Intermediate)

B. ANIMAL TRACKS

Find animal tracks in snow, mud, or sand (dog, cat, horse, cow—or wild animals where available). Identify, if possible, but this is not necessary. Measure the distance between tracks—there are several ways this can be done.

1. Measure from one track to the next.
2. Measure the track of a particular foot from one print to that foot's next track.

Try for a variety of tracks—different dog tracks may be of different sizes and should give different measurements. Was the animal walking or running? How many steps would this animal have to take to go 100 yards, 100 meters, a kilometer, a mile? How many steps to go from where you found its tracks to Los Angeles or Washington, D.C., or other locations in our state. If the animal makes a certain number of tracks per minute, how long would it take it to travel these distances? Graph and/or chart the data from the different animals. Now, compare to several of your schoolmates. (*Concepts 1A, 1B, 2D*) (Primary, Intermediate)

C. ACRES — HECTARES — SQUARE MILES: BUFFALO

Arizona has two buffalo ranches; one east of Flagstaff and one on the north rim of the Grand Canyon. Raymond Ranch, near Flagstaff contains 15,717 acres; Houserock Ranch, 67,530 acres. How many square miles are in each ranch? Arizona buffalo ranges are sagebrush-grasslands, and are essentially poor range. On an annual basis, it takes 277 acres of this quality of range to support one buffalo. How many buffalo can live on the Houserock Ranch? Raymond Ranch? Each buffalo consumes about 35 pounds of plant food per day, 365 days per year. How much does a buffalo eat in a year? How much do the buffalo on Houserock Ranch eat in a day? A year? How about Raymond Ranch?

Convert acres into hectares. Convert hectares into square kilometers. Convert pounds of feed into kilograms. How many buffalo can live on the two ranches? How much food is necessary to feed them all for one day, one week, one month, a year? (*Concepts 1C, 1E, 5A*) (Intermediate, Junior High)

D. DRINKING WATER

All over the desert areas of the west, wildlife agencies have built waterholes for desert animals. One of the animals most in need of such water is the Desert bighorn sheep. During the hottest summer months, ewes (female sheep) and lambs come to water almost daily. Rams (male sheep) sometimes do not come to water for nearly a week at a time. These rams may travel 20 miles to water. So, if the rams travel 20 miles to water, they have already traveled 20 miles from water, and perhaps 5 miles per day during the week away—that's about 65 miles of travel between drinks. The rams are believed to drink approximately 4 gallons of water when they do come to water. How many miles to the gallon does a ram get? If ewes and lambs come to water daily and a ewe drinks 1 gallon and a lamb drinks 2 pints, how much water does a ewe and her lamb drink per week?

How much water must be available in the waterhole for 10 rams, 16 ewes, and 7 lambs for the months of June, July, and August? (*Concept 1D*)

(Intermediate, Junior High)

E. BURROS DRINK WATER TOO!

One wild burro, having been without water for 36 hours, and, having traveled at least 20 miles, came to the waterhole. A wildlife biologist was keeping track of this burro in order to learn about his way of life. The biologist wanted to see how much water the burro would drink and had prepared an experiment. In 5 minutes at the water, the burro drank 12.2 liters of water. How much did he drink per minute? How much water did this burro need per day? How many gallons is 12.2 liters? If this burro was drinking at the same waterhole as the bighorns (in activity D), how much larger would the waterhole have to be? If he was only one of a herd of 18, how much water would the herd need per day, and for the three summer months? Do you think this competition between burros and bighorns could become a serious situation in dry years? (*Concepts 1C, 1D*)

(Intermediate, Junior High)

F. DESERT TORTOISE

A desert tortoise has been known to drink up to 40 percent of his weight in water. Weigh a desert tortoise. Figure out the weight of water he could consume. How many centiliters of water? Deciliters? Could he drink a liter? Where does a tortoise usually get most of his water? (From plants that he consumes.) More problems could be made by weighing green plants and then drying them to determine percentage of water in each type of plant. (*Concepts 1A, 1D*)

(Intermediate, Junior High)

G. PREDATOR-PREY

Using the information provided, students should calculate answers to the problems listed.

Given:

One acre of meadow can produce 500 pounds of forage per year.

One acre of chaparral can produce 300 pounds of forage per year.

One acre of forest can produce 100 pounds of forage per year.

(Forage: refers to vegetation taken naturally by herbivorous animals, both wild and domestic.)

One adult deer requires 3650 pounds of forage per year, and for the purposes of this problem, 53% of this forage comes from the chaparral, 39% from the meadow, and the remainder from the forest.

NOTE: These figures are realistic but will vary widely, depending upon local conditions, such as rainfall.

Problems:

1. How many deer can be supported on the area shown? (Conversion factor: one acre = 10 square chains.)
2. How could vegetation be manipulated if your goal was to increase the deer population?
3. What percentage of this deer habitat would be lost if the proposed freeway is built? How many less deer would there be on the area?
4. If the deer need chaparral, meadow, and forest vegetation, how many deer can live east of the freeway? What percentage of the total herd would the freeway eliminate?
5. What percentage of this deer habitat would be lost if the proposed summer homes were built? (The development takes up one-eighth of the forest.) How many deer would be eliminated by the summer home development?
6. What vegetative changes would occur if the timber was harvested by clearcutting? Partial cutting? Section cutting? What effects would these vegetative changes have on the total deer herd?
7. If you were a Forest Ranger, managing the forest for timber production, and the deer herd increased, what effect might this have on new tree seedlings?
8. If the freeway was built, the summer homes developed, and the forest partially cut, how big is the present deer herd? What is the percentage of reduction?

Social Studies

A. BE A PIONEER

Today we often hear of the "unspoiled continent which was invaded by the European settlers who raped and ravaged a virgin land." It is important that we look at this understanding, relative to those times and conditions. We must first "walk a mile in their moccasins."

Our forebears, as they cleared land, built homes, developed communities, and used available resources, did not see themselves as abusers of the land—and were not regarded as such by their contemporaries. They acted in ways that were consistent with the circumstances in which they found themselves and with their heritage. They came from a world where wildlife belonged to the king and where forests were plainly finite. They came to a world where forests seemingly were limitless and, in some areas, wildlife was equally beyond numbers. When flights of Passenger pigeons took hours to pass, and darkened the sky, how could they conceive of a limit to that resource? Our ancestors made many mistakes in their use of land and its resources, but this only became apparent later, when viewed by people far removed from the conditions of the time. Hindsight is always better.

This activity explores the pioneer rationale and philosophy of resource use. Students should attempt to understand the attitudes of the pioneer toward his environment.

Divide your students into small groups who will represent families moving to Arizona in 1820. Have them "homestead" various areas of the state. Have some settle in the White Mountains, some along the Colorado River at the confluence with the Gila, settle the San Simon Valley and the Hualapai Valley. A later comparison of situations and conditions will be very interesting.

Research:

Research existing conditions—vegetative cover, wildlife in the area. Are there Indians nearby and what is their attitude toward you? Research some of these things through reading: Lieutenant Beale's report on the survey of railroad right-of-ways across northern Arizona; the essays on "Escudilla," "Thinking Like a Mountain," and "Green Lagoons" from the *Sand County Almanac*, by Aldo Leopold; "A Soldier-Scientist in the American Southwest," Monograph No. 1 from the Arizona Historical Museum; *The Journal of Arizona History*; "Campfires on Desert and Lava," by Hornaday. Look at pictures in "The Changing Mile," by Hastings and Turner; U.S.D.A. Miscellaneous Publication No. 321, "To Hold This Soil," by Russell Lord. There are many references which will give true pictures of life as it really was in those times.

Given:

The family has brought seeds and livestock; all of their resources are in the wagon they drive and the livestock driven behind. Students should make lists of these resources. Make judgments as to weights and whether or not they could *all* be carried in the wagon. What would be left behind?

Once the potential homesite is found, what considerations are there in reference to specific location? What qualities need to be considered? (Slope, drainage, soil type, water, shelter, vegetation, exposure, elevation, etc.)

What are the pioneer's priorities now that he has arrived? List these in order of priority. Take each priority and describe in detail how it would be accomplished. The family may not exceed their own physical capacity to accomplish, nor can they use resources that are not included in their wagon or naturally available. Have students describe processes of getting food, building shelter, providing defense against unknown enemies—animal and human.

Now, have students describe the environmental impact of each activity—the cutting of trees, clearing land, taking wildlife, etc. (Do not warn the students about this step—let them use the land and live on it first.)

When students have completed a study of their impact upon the environment, hold a class discussion on these questions:

1. As a pioneer, what was your attitude toward the land and its resources when you were developing your homesite?
2. Were you much concerned about your impact upon the environment?
3. How does your attitude, as the real you, compare with your pioneer attitude?
4. What factors have contributed to attitudinal changes since those days?
5. Is it unfair or unreasonable to call the pioneers "unthinking despoilers"—that they were "bad guys" because of what they did to the land? Why, or why not?
6. Do you think national attitudes have changed?
7. Should we attempt to judge our actions affecting the environment by current standards and conditions, or by the needs of future generations? What is your reasoning? (*Concepts 5A, 5B, 5C, 5D, 5E*) (Junior High, High School)

B. WHO CARES ABOUT WILDLIFE?

Invite representatives from various conservation organizations to meet your class (such as National Audubon, Arizona Wildlife Federation, Sierra Club, Friends of Animals, etc.). Be sure they are aware of your format and perhaps you may want to give them the questions your students will lead-off with.

Prior to the visit, involve the whole class in formulating questions to be asked by a panel of students in an interview-type program. Schedule the time frame and the number of questions to allow dialogue between the rest of the class and your guest.

Sample questions could be:

1. What is your group's primary objective in regard to wildlife conservation?

2. What is the scope of your organization—statewide, national, international?
3. What is your membership? Is your organization growing or declining in numbers?
4. Do you lobby for legislation and causes?
5. Do you publish a magazine or newsletter? How is it available?
6. What technical expertise does your group have available for your work?
7. What is your annual budget?
8. What are some of your major accomplishments?
9. What areas of concern are you focusing on at this time?
10. What is your position on Wildlife Management?
11. Do you support or oppose the concept of legal, controlled, sport hunting?

After your guest has gone, lead the class in a discussion of the group represented.

Suggestions:

1. Do citizen groups better represent the people in matters of wildlife conservation than governmental agencies? Cite evidence to support your opinion.
2. Is the decision-making process improved or impeded by input from citizen conservation groups? Are quick decisions good or bad? What conditions determine the quality of a decision regarding wildlife conservation?
3. If these groups support or oppose a project, are they of value to society? If so, how? Cite evidence.

The same procedure could be followed, bringing in representatives from industries whose activities may have impact upon wildlife: the forest industry, mining, livestock, or any others who deal with land and/or resources.

Other sources of guests are state and federal agencies—but these people are usually far understaffed and find it very difficult to accept such assignments. Perhaps some study of such agencies could be made, and the students could then role-play the parts of agency representatives. (*Concepts 4A, 4E*) (Junior High, High School)

C. WHAT IS THE LAW?

What laws protect and control the use of Arizona's wildlife? Who administers and enforces these laws? What is the process of enforcement and adjudication? What courts handle wildlife law violations? What are the maximum penalties for the violation of these laws?

Have students discuss the wildlife laws of Arizona without researching them ahead of time. Have them discuss and record the laws as they think they are.

Obtain a copy or copies of section 17 of the Arizona Revised Statutes (copies of a synopsis of these laws are available in quantity from Game and Fish Department offices). Have students compare what they thought the law was to what it really is. Look carefully at the definitions used in the law; these are the legal interpretation of these words. These definitions seldom match Webster's, and often, not even common understandings.

Questions for consideration:

- Do you agree with the laws as they are?
- Who makes laws?
- Who makes regulations?
- Do such regulations have the force of laws?
- What is the difference?

Assign groups to rewrite various sections of the law as they think it should be.

Trace the history of wildlife laws in America, in the world. (See Chapter 1 of "Game Management," by Aldo Leopold and pages 1-13, "Wildlife Law Enforcement," by William Sigler.)

Questions:

- What were the first conservation laws?
 - Starting with protection alone—what other steps have gone into putting us where we are today in wildlife conservation?
 - Is America ahead of, or behind, the rest of the world in this area?
- (Concept 4E) (Junior High, High School)

D. THE VALUE OF WILDLIFE

Divide your class into two groups. One group will investigate the amount of money spent in your community by hunters and fishermen; the second, the amount spent for nonconsuming "users" of wildlife such as photographers, bird watchers, and artists.

Students will use the classified section (yellow pages) of the telephone book as a resource to compile two lists; one of local businesses which cater *directly* to outdoor activities (sporting goods stores, meat processing establishments, photography shops) and the other of businesses *indirectly* related to these "users" of wildlife (motels, service stations, bookstores).

Students should visit businesses on the list and interview the owners or employees to find out what percentage of their income derives from wildlife-related activities. (In smaller communities, particularly in the mountains, this figure may be substantial: Yuma, Arizona motel owners attributed more than \$1,000,000 of their income to visiting hunters during only the first seven days of dove season.)

After students have completed their interviews and tabulated their data, discuss these questions:

1. Which form of wildlife use, consuming or nonconsuming, contributes the most to the local economy? Will it continue to contribute the most? Why or why not?

2. Where does the money go which is generated by hunters and fishermen? By nonconsuming users?
3. Does the money spent by either of these groups of users of wildlife represent the real value of wildlife to you? To the community? To the biosphere?
4. Does an endangered species have any value? If so, how would you measure the value? If not, why not? (*Concepts 4A; 4C, 4E*)

(Intermediate, Junior High, High School)

E. SHALL WE SPRAY?

Ask students to read and respond to this situation:

"Those damned insects have to be stopped before they destroy the whole citrus crop. Whenever one of those bugs bites into an orange, it leaves a spot—doesn't hurt the fruit a bit—but it marks the skin and people just won't buy a spotted orange. If we don't get in there and spray soon we will lose the crop," stormed the farmer.

"I understand your problem," replied Bob Hartley, the local Wildlife Manager. "But you can't use the poisons you have in mind. I know they are very effective in protecting your oranges, but they are persistent and carry throughout the ecosystem. They destroy the predaceous insects, lizards, and amphibians who eat lots of insects, and we have a lot of different kinds of birds nesting and feeding in the citrus groves. When they eat insects that have died from your poison—and one bird may eat hundreds in a single day—the birds get a terribly heavy shot of the same stuff. If it doesn't kill them directly, it sooner or later affects them via the thinning of egg shells, weakening of newly-hatched birds, or malfunctions. And when we lose the birds, the predatory insects, and these other insectivores, we *really* get an explosion of insect life—not just in the citrus grove—but in the whole neighborhood."

"But this is the only stuff that works fast enough, and hits hard enough, to do the job," the farmer explained. "When those bugs hatch, we catch hell right away. I sure don't want to bother those birds, or those other critters either—but dang—my livelihood depends on this fruit being top quality. If I don't spray, my kids don't eat."

Hold a class discussion on these questions:

1. What can these men do to solve their problem? What are their choices? Does either have alternatives available he has not expressed? If so, what are they?
2. How would you resolve this dilemma? What information do you need before making your decision? On what criteria would you base your judgment? What legal constraints and procedures must be considered?
3. Is there something about the quality of oranges that we could perhaps deal with? Would this be a help?

In their search for alternatives and solid criteria, encourage your students to consult the references cited under Resources.

VARIATION:

After students are familiar with the situation described, divide your class into three groups: the first will advocate the use of DDT; the second will oppose its use; the third will represent the United States Environmental Protection Agency..

The first two groups will research and prepare testimony to be heard by the EPA panel. The panel will decide if the situation warrants issuing an emergency permit for the use of DDT, in accordance with the 1972 regulations banning the chemical.

Students preparing for the "hearing" should consider:

1. The economic implications and long-range environmental impact of granting or not granting the permit.
2. Alternatives or compromise solutions to the problem.
3. The EPA criteria which must be met before the use permit can be approved. (Students role-playing the EPA should research and establish these.)

Resources:

Special Note on Sources and Dialogue: While the above dialogue represents a hypothetical situation, the data regarding the effects reflect the results of actual research. For a review of actual case histories see:

Rudd, Robert L., *Pesticides and the Living Landscape*, (Madison, Wisconsin: University of Wisconsin Press, 1966) p. 106-109.

The original research was reported by:

Crowter, R. A. and E. H. Vernon, "Effects of Black-Headed Budworm Control on Salmon and Trout in British Columbia," *Canadian Fish Culture*, No. 24:23-40 (1959).

Keenleyside, M. H., "Effects of Spruce Budworm Control on Salmon and Other Fishes in New Brunswick," *Canadian Fish Culture*, No. 24:17-21 (1959).

Kerwill, C. J., "Effects of DDT Spraying in New Brunswick on Future Runs of Adult Salmon," *Atlantic Advocate*, Vol. 48, No. 8, p. 65-68 (1958).

Moreover, because of the considerable quantity of popular literature available on the effects of DDT (most of it less than objective in its presentation), only a highly selected list is given. Further information is extensively referenced in these documents:

Articles -

Edwards, J. G., "One Step Beyond: An Inquiry Into Research on DDT." Available from the Terra Society, P.O. Box 110, Mt. Prospect, Illinois.

Hinckley, A. D., "The Gypsy Moth," *Environment*, Vol. 14, No. 2, (March 1972) p. 41-47.

McCaull, Julian, "Questions for an Old Friend," *Environment*, Vol. 13, No. 6 (July/August 1971) p. 2-9.

McIntire, Greg, "Spoil by Success," *Environment*, Vol. 14, No. 6 (July/August 1972) p. 14-29.

Pamphlets —

U. S. Forest Service, "Major Outbreaks of Douglas Fir Tussock Moth in Oregon and California," (Portland, Oregon: Pacific Northwest Forest and Range Experiment Station, 1973) General Technical Report PNW-5.

U. S. Forest Service, "Surveillance Report 1965 Burns Project Douglas Fir Tussock Moth Control," (Washington, D.C.: G.P.O., 1968) S/N 994-184.

Simulation/Games —

The Tussock Moth Issue available from Georgia-Pacific Corporation, 900 S.W. Fifth, Portland, Oregon. Attention: John Thompson. Prepared by the Portland Metropolitan Environmental Education Council.

(Concepts 5A, 5B, 5C, 5D, 5E, 5H)

(Junior High, High School)

Science

A. WHY DOES IT LIVE HERE?

Divide the class into 10 groups. Assign each group one of the *biotic communities* of Arizona: Southwestern *Desertscrub*, Great Basin *Desertscrub*, *Desert Grassland*, *Plains Grassland*, *Mountain Grassland*, *Chaparral*, *Evergreen Woodland*, *Deciduous Woodland*, *Coniferous Forest*, or *Alpine Tundra*.

Each group is to demonstrate, with maps, charts, and graphs, why this community exists where it does, and what distinguishes it from other communities. Maps, charts, and graphs may show: geographic features; vegetation; rainfall; area covered by community; growing seasons; altitude; highest, lowest, and mean temperatures. List species of wildlife native to the area. (Wildlife includes birds, insects, mammals, reptiles, amphibians.)

*Reports should attempt to answer these questions:

1. What wildlife species are found in this community?
2. How is the wildlife of the community influenced by the vegetative complex?
3. How does rainfall affect wildlife?
4. Which Arizona community has been most affected by modern man? Least?
5. Which community appears to have the greatest variety of wildlife? The most varieties of plants?
6. Define a desert. Which community most clearly fits your description?
7. Are there species which occur in more than one community? In all communities? Which ones?

An excellent resource book for this activity is *The Vertebrates of Arizona*, by Charles H. Lowe, University of Arizona Press. Most of the information can be found in this one book. (*Concepts 1A, 1B*) (Intermediate, Junior High, High School)

B. HOW MANY CALORIES IN A DEER?

Students should use cookbooks or other resources to find the caloric (energy) values per gram of various meats. Deer meat is usually lean and may be compared to lean beef, if it is not specifically mentioned in resource materials.

Students will compute the number of grams of deer meat needed to obtain one calorie of energy, and make a bar graph illustrating this information. (Caloric values may also be determined by experiments—see BSCS and IPS experiments on burning nuts.)

Compare cost per calorie, again using beef as a cost reference as deer cannot be legally sold in Arizona. Depict this information on a graph.

In 1976, there were 13,391 deer harvested in Arizona by hunters. If the average deer weighed 107 pounds (dressed weight), how many calories were available to Arizona households? Using beef as a price equivalent, how much was this deer meat worth?

Hold a class discussion on these questions:

1. What is the relationship between cost and energy values? How would this compare to vegetable foods?
2. What is the relationship between cost per gram and grams per calorie?
3. Is plant or animal food higher in energy per gram?
4. What other animals appear on Arizona dining tables? Investigate quantities and subject them to the same processes you have just done with deer meat. (Resource—Arizona Game and Fish Department Annual Harvest Data.)
5. Is this wildlife a valuable food resource?
6. How else does wildlife serve as a usable, renewable resource?
(Concepts 4A, 4C, 4D, 4E) (Intermediate, Junior High, High School)

C. RARE AND ENDANGERED SPECIES OF ARIZONA

This is a simple listing of species or subspecies which are categorized as in danger of being eliminated from Arizona.

For more complete information contact the Arizona Game and Fish Department for their publication "Threatened Wildlife in Arizona."

Mammals

- Yuma Mountain Lion (*Felis concolor browni*)
- *Sonoran Pronghorn (*Antilocapra americana sonoriensis*)

Birds

- Mississippi Kite (*Ictinia mississippiensis*)
- Gray Hawk (*Buteo nitidus*)
- *Southern Bald Eagle (*Haliaeetus leucocephalus leucocephalus*)
- *Peregrine Falcon (*Falco peregrinus anatum*)
- *Yuma Clapper Rail (*Rallus longirostris yumanensis*)
- Black Rail (*Laterallus jamaicensis*)
- Rose-throated Becard (*Platyparis aglaiae richmondi*)
- Buff-breasted Flycatcher (*Empidonax fulvifrons pygmaeus*)

*On Federal Endangered List

Fishes

- *Humpback Chub (*Gila cypha*)
- Mexican Stoneroller (*Camptostoma ornatum pricei*)
- *Woundfin (*Plagopterus argentissimus*)
- *Colorado River Squawfish (*Ptychocheilus lucius*)
- Loach Minnow (*Tiaroga cobitus*)
- Yaqui Topminnow (*Poeciliopsis occidentalis sonoriensis*)

Ask each student to select a species from the list and gather information about its problems. Reports should include this information:

1. Past and present range of species.
2. Past and present population data, as available.
3. Length of time it has been endangered.
4. Reasons for being on the list.
5. Actions currently being taken to improve its chances of survival. Do you think these actions will be successful?
6. A list of agencies, interest groups, or others who are working on the problem. Who is contributing money to the effort? How is this money contributed?
7. Activities that individuals, or the class, might undertake to aid the species.
8. Describe ways in which good land management could slow down or prevent such losses.
9. Why is it important that this species survive?
10. What is the primary problem of all of the species investigated—is there a one-word answer?

VARIATION: (Or follow-up activity)

Have students design a hypothetical animal with characteristics which would favor extinction. How do the traits of this species compare with those of any real animals? Now design a species that is highly resistant to extinction.

See article in *Environment*, December 1974, by Uetz and Johnson, "Breaking the Web." (*Concepts 1A, 5A, 5B, 5C, 5H*) (Intermediate, Junior High, High School)

E. ANIMAL SOUNDS

Tape an assortment of animal sounds, leaving out any identification. Try to pick sounds you do not think they will readily identify. Try some of the owl calls (but not the Great horned owl), elk, frogs and toads, strange birds such as Coppery-tailed Trogons and the Prairie Chicken.

Play these sounds for the students—don't comment on what the sounds are, just let the students listen. Then tell them that each sound is made by an animal and let them hear the sounds again.

Have each student design an animal to fit one of the sounds. Allow them to choose a sound that appeals to them and draw an animal to fit it. These animals can be realistic or purely imaginary. Allow the tape to keep playing as the students make their drawings.

When all drawings are complete, play the tape and identify each animal. Have students match drawings to sounds.

Records:

"Voices of the Night," Houghton-Mifflin; "The Swamp in June," Droll Yankees, Pomfret, Vermont; and "A Field Guide to Western Bird Songs," Peterson series, sold by Audubon. Other records can be found in libraries. (*Concepts 1A, 1B*)
Primary, Intermediate, Junior High, High School)

F. CAMPUS SAFARI

Take students on a "pretend safari" around your campus, in the neighborhood, or to a park.

Pretend that buildings are great boulders or mountains. Search the nooks and crannies for living things. Many of them are very small, so search carefully.

Is the shrubbery similar to a forest understory? What signs of life can be found here? Look on the undersides of leaves and on twigs and stems.

Are the trees a little like a forest? Will you find different kinds of life here?

Look for these living creatures or their signs. Use hand lenses to see them better. Make drawings of what you see. These things you see are also "wildlife"—insects and other

small creatures live under the same rules of nature as bears, deer, or robins. Learning about these more-easily found animals leads to a better understanding of all animal life—including man.

NOTE: Bring back only memories, your notes or drawings, and photographs—leave only your footprints. This is good training for later visits to wildernesses and great natural wonders in the out-of-doors. And remember, other classes might like to have the same adventure as you have had, and find the same wonderful things you have found. (*Concepts 1A, 1B, 1D*) (Primary, Intermediate, Junior High)

Industrial Arts

A. DESIGN A DEN

Have students design dens for various species of Arizona wildlife. Research the animal for specific size, conformation, size of hole it can get through (a cat can get through any hole that it can stick its head through), climatic conditions in the animal's environment, what denning materials does it use and how, locations of dens, exposure. Why does this species den and what are its requirements in its den? What time of year does it den? *Nocturnal or diurnal?*

Students could investigate rodent, or other, dens as available. They can take internal and external temperatures, and dig dens out. This should be done carefully so as to be able to see the complete structure.

An excellent reference would be *Field Guide to Animal Tracks*, by Olaus Murie—a Peterson Field Guide.

Have students make scale models of dens from their designs. These could be made from plaster of paris or paper mache.

Discuss:

Should man be a "denning animal" in the southwestern deserts? How would this affect our energy use? Water consumption? Resource use in building materials? (*Concepts 1A, 1D, 1E, 1F*) (Intermediate, Junior High, High School)

B. FOR THE BIRDS

Have students devise and follow through on a plan to mass produce birdhouses. Design several different models. Consider all problems of materials and equipment needed, logical production procedures, potential rates of production, markets for products, costs, sales prices, profit percentages, and the distribution of profits (could they be donated to the local Audubon Chapter, Sierra Club, or state wildlife agency?)

A birdhouse is not just a box with a hole in it for the bird to get in and out. Some real investigation needs to be made of the following: What bird or birds are we building for? How large should the box be? What size should the entrance holes be? Where will the nest box be placed? How high off the ground? Are some protective devices needed?

Students might do some of this research as a part of a biology class. Certain testing could be done: nest boxes facing different directions, different elevations, and different locations. Which are most acceptable to the species?

Follow up the production with a total marketing process—advertising, bookkeeping, tax considerations, etc.

A second project could be bird feeders.

An excellent reference is *One Hundred and Two Bird Houses and Feeders You Can Build*, by Sibley. Available from Reed and Sons, Box 150, Route 2, Perrysville, Ohio 44864. (Concepts 1A, 1D)
(Junior High, High School)

C. INSULATION IS FOR THE BEARS

Using the table provided, ask students to calculate the answers to these questions:

1. How many times more efficient is wood than stone as insulation?
2. How many inches of stone would be required to insulate as well as two inches of wood?
3. Is a woodpecker's nest in the heart of a 10-inch-diameter tree better insulated than a bear den inside three-foot-thick rocks?
4. How thick would the walls of the bear den have to be to be better insulated than the woodpecker nest?
5. Design an experiment to determine the insulation value of soil vs. wood or stone.
6. How deep would a rodent den need to be to reduce a ground surface temperature of 100° to 85°?
7. Design an experiment to test the insulation value of a saguaro cactus vs. wood, stone, or earth.
8. Is the retention of heat important in the insulation of a nest or den?
9. Compare these efficiencies with the materials in your home.

(See chart on next page)

Material	Percent Efficiency
Wood	100.0
Stone	6.4
Cinder Block	22.4
Common Brick	16.0
Aluminum	.06
Air Space*	77.6

*Air Space 3/4 to 4 inches in thickness

(Concepts 1A, 1C, 1D)

(Intermediate, Junior High, High School)

VOCABULARY

- adapted-adaptation* – The process of making adjustments to the environment. Forests develop only where soil types, moisture, and sunlight are balanced to the proper degree. Desert plants have made adjustments so as to be able to live under intense sunlight, on poorer quality soils, and with a much reduced water supply.
- aerate* ('a(-e)r-'at) – To supply with air or oxygen. To supply the blood with oxygen as is the function of lungs. To supply running water with additional oxygen as when a stream runs over falls or rapids, or when wind creates waves on a lake.
- amphibian* (am-'fib-e-en) – Animals that live partially in an aquatic habitat and partially on dry land. Includes frogs, toads, and salamanders.
- animal communities* – Animals of various species live within a certain habitat, each occupying a specific position in this particular environment. Directly parallel and related to plant communities. In a desert area, a coyote, jackrabbit, gopher, snake, elf owl, gecko, scorpion, and a cactus wren may be part of an animal community.
- annual turnover* – The rate of replacement of individual animals in a population. Birds, such as quail, may have a 70 percent turnover annually. This means that only 30 percent of the birds alive at the beginning of one year are still alive at the end of the year. The reproductive capability of a species will match the mortality, or turnover, rate.
- aquatic* (e-'kwat-ik, -'kwat-) – Growing, or living in, or frequenting water.
- bag limits* – The regulation of numbers allowed in regulated hunting or fishing. A hunter may take 10 mourning doves; a deer hunter may take one deer per year; these are bag limits.
- biome* ('bi-'om) – A large geographic area with somewhat uniform climatic conditions. Over a period of time certain plants have adapted themselves to live under these conditions. These plants are dominant in this biome and the biome usually gets its name from one of these dominant plants; i.e., the Forest biome, the Grassland biome, etc.
- biotic community* – Commonly, the living organisms in a given community. It would include all plant and animal life within the community. The nonliving parts would be considered the abiotic parts of the community.
- blind* – A hiding place for observing; "a woody place." Usually in Arizona it is used in reference to large, thick stands of mesquite trees and usually in bottomland areas.
- bosque* ('bask) – A small wooded area—reference to mesquite bosques is to areas of almost mesquite "forests" adjacent to desert rivers, usually on flood plains.
- bounty* – A reward or payment for removing certain species of animals felt to be harmful. This action is slowly going out of practice.
- browse* ('brauz) – A general term, commonly used in wildlife management to signify brushy plants utilized by deer, elk, or cattle as feed. Some of these are listed under chaparral—others might be calliandra, hollyleaf buckthorn, garrya, or rosewood.

capillaries (kap-e-'ler-e) — Any of the smallest vessels of the blood-vascular system joining the arterial and nervous systems and forming networks throughout the body.

carnivore ('kar-ne'vo(e)r, -'vo(e)r) — Referring to meat eaters. A carnivore is a meat eater.

carrying capacity — The ability of a given unit of habitat to supply feed, water, cover, and necessary space to a wildlife species. The largest population the unit can support on a year-round basis, or during the most critical season. Varies throughout the year. This number varies from year to year, dependent on conditions within the habitat such as rainfall, competition from domestic animals, etc.

chaparral (shap-e-ral) — In wildlife work we use the term as descriptive of brushy areas where manzanita, ceanothus, cliffrose, scrub oak, skunk brush, and others are the predominant vegetative types. The term originates from the Spanish and referred to thorny bushed and is also the source of the word "chaps," a part of the cowboy costume. Chaps were originally called chaparreras and later shortened by Anglo cowboys.

climatic (adj.) — The average condition of the weather as defined by temperature, precipitation and wind velocities; the environmental conditions relating to weather.

climax — The final stage of plant or animal succession. When environmental conditions have been stable long enough for an area to develop a semipermanent biome. Rock crumbles, pioneering plants begin to grow in the sandy soil; as they add mulch and humus, other plants follow—from grasses to shrubs, to pine forest. If climatic conditions and soil types are proper, the climax species could be the pine forest. Animal types would follow this pattern of succession, ending perhaps with squirrels, porcupines, and Stellar's jays as climax species.

community — An association of organisms, plant and animal, each occupying a certain position or ecological niche, inhabiting a common environment, and interacting with each other.

coniferous (ko-'nif-(e)res, ke-) — Refers to cone-bearing; a coniferous forest is one composed of pines, firs, or spruces.

conservation-wildlife — The conservation of a renewable resource recognizes that the resource replenishes itself periodically, and that surpluses occur for short periods. These surpluses may be used without damage to the basic resource.

consumer — The first part of an ecosystem is the nonliving substance; the second part consists of those organisms which are called "producers" or food makers; part three of this system is called the "consumer" because it utilizes the producer for its food. It may in turn be used as food by a secondary consumer. A rabbit is a primary consumer. A fox would be a secondary consumer.

cover — The vegetation, debris, and irregularities of the land that provide concealment, sleeping, feeding, and breeding areas for wildlife.

covey ('kev-e) — A small flock or group, often a family group, of birds such as quail.

- dabbling ducks* — Ducks which frequent shallow marshes, ponds, and rivers and "tip up" to feed. They feed with body above the water and take off vertically when startled. Also called "puddle ducks." (See diving ducks)
- deciduous* (di-'sij-e-wes) — In reference to trees—those that annually shed their leaves; regarding animal teeth—those commonly called "milk teeth."
- decomposer* ('de-kem-'po-zer) — Those organisms (bacteria-fungi) which convert dead organic materials into inorganic materials.
- deposition* ('dep-e-'zish-en, 'de-pe-) — The depositing of materials, usually soil particles, by flowing water.
- depredation* ('dep-re-'da-shen) — The act of preying upon; usually in relation to wildlife damage to man's crops or animals.
- desert scrub* — Arid environments with irregular winter rainfall, summer rainfall, or 'biseasonal rainfall; highly varied plantlife, with leafless, drought deciduous or evergreen species of trees, shrubs, herbs and grasses, yuccas, agaves, and cacti.
- diurnal* (di-'ern-^{el}) — Active by daylight; the opposite of nocturnal.
- diving ducks* — Ducks which prefer deep water as in lakes and bays. They feed by diving below the surface and take wing from a running start.
- dominant species* — Plant or animal species which exert major controlling influence on the community. Removal of dominant species result in important changes in the community. Generally, dominants which have the greatest total biomass. (Biomass: total numbers or weight.)
- ecological niche* ('nich) — That special place in a community occupied by a given organism. Where an organism lives, where it gathers food, where it seeks shelter. Who are its "friends and enemies," what does it give to the community, what does it take from it, how is it affected by its environment, and how is the environment affected by it? These determine the "place in society" of this organism.
- ecology* (i-'kal-e-je, e-) — The study of the relation of organisms or groups of organisms to their environment; or the science of the interrelations between living organisms and their environment.
- ecosystem* — Any natural unit that includes living and nonliving parts interacting to produce a stable system in which the exchange of materials between the living and nonliving parts follow circular paths.
- edge effect* — The tendency of wildlife to concentrate at the edges of two adjacent vegetative or land-use types. Where deer, for example, concentrate in an area where brush land and meadowland meet because of the extra food and shelter provided by the edge.
- endangered* — An "endangered" species is one which is in danger of extinction throughout all or a significant portion of its range. (A threatened species is one that is likely to become endangered.)

environment — The total of all of the surroundings: the air, water, plantlife, human element, wildlife—all that has influence on you and your existence. Both physical and biological factors.

esthetic (aesthetic) — Relating to or dealing with the beautiful. An esthetic value relates to the value placed on beauty.

exotic — In conservation language this refers to a foreign plant or animal that has been introduced into a new area. Examples in Arizona would be Rainbow trout or White-winged pheasant.

extinction — The act of removing from existence. An animal facing extinction is one in danger of vanishing from our world.

feral ('fer-el) — Used in wildlife as referring to domestic animals gone wild; i.e., burros and "wild" horses, cats, dogs, and swine.

finite — Having bounds or limits; capable of being counted or measured; the opposite of infinite.

flyway — Flight routes established by migratory birds.

food chain — The transfer of food energy from the source in plants through a series of animals, with repeated eating and being eaten.

food web — Food chains (see above) are not isolated sequences but are interconnected with one another. This interlocking pattern is called the food web.

forage ('for-ij, 'far-) — Refers to vegetation taken naturally by herbivorous animals, both wild and domestic.

forbs ('fo(e)rb) — In wildlife usage forbs are weeds and herbs; low-growing annual or perennial herbaceous plants. An important part of wildlife habitat.

habitat — The complex of soil, water, and plants, commonly called "cover" in which all wildlife exists. It is the "life range" which must include escape cover, winter cover, food and water, cover to rear young, and even cover in which to play.

herbivore ('(h)er-be-'vo(e)r, -'vo(e)r) — An herbivore is a plant eater.

hibernation ('hi-ber-'na-shen) — The act of passing the winter, or a portion of it, in a state of sleep; a torpid or resting state.

insectivorous ('in-'sek-'tiv-(e)-res) — Refers to insect eaters.

interaction — The relationship of one organism to another. The action of one population affecting the growth or death rate of another population. One population may eat members of the other populations, compete for food, excrete harmful wastes, or otherwise interfere with the other population. Some interactions are positive, some negative, and some completely neutral.

interdependencies — The interrelationships of wildlife with one another and with the various elements of their environment.

invade — To enter, to encroach upon, to spread over into. Wildlife use usually refers to when an organism is removed from a community and another organism spreads over into this community.

lichens ('li-ken) — Algae and fungus growing together in a symbiotic relationship. (Symbiotic: mutually beneficial in this case.) (See mutualism)

limiting factors — There are many influences in the life history of any animal. When one of these exceeds the limit of tolerance of that animal, it becomes a limiting factor. It then drastically affects the well-being of that animal.

microclimates ('mi-kro-'kli-met) — The climates of specific small areas are called microclimates. Microclimates are the tiny contrasts to the general climate of the area. A deep, narrow, shadowed canyon—cool and damp— might be a microclimate within a desert mountain range. The shady side of a huge boulder, or the area immediately surrounding a tiny spring would be classified as microclimates.

microorganism ('mi-kro-'or-ge-'niz-em) — An organism microscopic in size. Able to be seen only through a microscope.

migratory — In wildlife, birds or other animals which make annual migrations; may be great distances or very short distances, depending on species.

mitigate ('mit-e-'gat) — To make up for; to substitute some benefit for losses incurred.

mulching — To add materials to soil in order to protect from cold, to reduce evaporation, to control weeds, or to enrich the soil. Common materials could be sawdust, bark, leaves, cotton linters, etc.

mutualism ('myuch-(e)we-'liz-em, 'myu-che-'liz-) — A close association between two different species whereby each species derives some benefit. The Yucca plant and the Yucca moth each benefit from their relationship.

natal — Related to birth or being born.

niche — See ecological niche.

nocturnal (nak-'tern-^{el}) — Active by night; the opposite of diurnal.

nonrenewable resource — Those resources which are nonliving—soil, minerals, water, and air; resources which do not regenerate themselves.

omnivore — An animal which eats both plant and animal material.

parasitic — To be a parasite on; mistletoe is a parasite growing on trees—it is parasitic.

plankton — Those organisms suspended in an aquatic habitat which control their own movements. Usually microscopic, and include bacteria, algae, protozoans, rotifers, larvae, and small crustaceans. Phytoplankton are the plant plankton; zooplankton are the animal species.

plant communities — An association of plants, each occupying a certain position or ecological niche, inhabiting a common environment, and interacting with each other. Dominant plants usually define the community; i.e., a spruce-fir community.

predator — An animal that kills and eats other animals.

prey — Animals that are killed and eaten by other animals.

primary producers — Green plants which are able to manufacture food from simple organic substances.

range — (a) Home Range: The geographic area in which a particular animal occurs. (b) An area grazed by livestock and/or wildlife.

raptor — Pertaining to eagles, hawks, and owls. Birds which are predatory; preying upon other animals.

renewable resource — Living resources, such as plants and animals, which have the capacity to renew themselves.

resident wildlife — Animals which are residents to a specific area on a year-round basis, as opposed to migratory.

scavengers ('skav-en-ger) — An organism that habitually feeds on refuse or carrion. A coyote is a part-time scavenger; a dermestid beetle is a full-time scavenger.

season (open season) — In wildlife conservation or management—that time when hunting or fishing is permitted for a particular species. May be a single day or year-round.

shelter — Cover; cover from elements, for natal activity, to travel in, for breeding, for bedding, etc. Varies depending on species.

slough ('slau) — An inlet from a river; backwater; tideflat; a creek in a marsh.

slough-off ('slef) — To shed; to discard as a snake or lizard shedding his skin.

social limits — The "saturation point" of a species in an environment. How much crowding will the individual accept. This will vary widely with species.

species — A population of individuals that are more or less alike, and that are able to breed and produce fertile offspring under natural conditions. A category of biological classification immediately below the genus or subgenus.

static — Showing little change, usually used in reference to a population or to a condition of habitat.

stewardship — The concept of land responsibility—that we do not own land but are managers of the resource and responsible to future generations for the condition of the land when we leave it.

stress — Usually thought of as a physical factor that applies to detrimental pressure to an organism or population. A drought period would apply a stress to a plant community and thereby to an animal population, and this would perhaps inhibit reproduction rather than eliminating the species.

succession — The orderly, gradual, and continuous replacement of one plant or animal by another.

"territorial imperative" – The instinctive compulsion to gain and defend a territory. Many zoologists believe this drive to be more compelling and persuasive than the sexual urge.

veldt – South African grassland, with scattered trees.

vermin ('ver-men) – Noxious or offensive animals. Animals that are undesirable to some element of our society. The term has been applied to rats, bears, mountain lions, etc. Usually used by someone with a specific but nonecological attitude.

viable – Capable of living, growing, and developing.

wapiti ('wap-et-e) – The Indian name for that member of the deer family that we normally call "elk."

waterfowl – Water birds, usually ducks, but includes shore and wading birds, geese, etc.

wildlife – As discussed in this manual, it pertains to all living animals.

BIBLIOGRAPHY

The following list has been carefully selected as to content regarding wildlife. Each of these books has been rated excellent by this standard. There has been no effort to evaluate other qualities of these publications although comments have been made in reference to readability and illustration.

The bibliography is subdivided into the following categories:

1. Field guides—general background, classification, and identification materials.
2. Activities, projects, experiments, collection, care, study.
3. Life histories, interrelationships, introductions to various species.

Field Guides:

Baranowski. *Golden Bookshelf of Natural History—Insects*. Golden.

Barker. *Familiar Insects of America*. Harper and Row.

Borror. *A Field Guide to the Insects*. Houghton, Mifflin.

Burt and Grossenheider. *A Field Guide to the Mammals*. Houghton, Mifflin.

Chinery. *Science Dictionary of the Animal World*. Watts.

Cockrum. *Recent Mammals of Arizona*. University of Arizona Press.

Conant. *A Field Guide to Reptiles and Amphibians*. Houghton, Mifflin.

Ennion. *Tracks*. Oxford.

Fisher, Simon and Vincent. *Wildlife in Danger*. Viking.

Fowle. *Snakes of Arizona*. Azul Quinta Press.

Hillcourt. *Field Book of Nature Activities and Conservation*. Putnams.

Kern. *Let's Look at More Tracks*. Putnams.

Klots. *New Field Book of Freshwater Life*. Putnams.

Lowe. *The Vertebrates of Arizona*. University of Arizona Press.

Minckley. *Fishes of Arizona*. Arizona Game and Fish Department.

Murie. *A Field Guide to Animal Tracks*. Houghton, Mifflin.

Peterson. *A Field Guide to Western Birds*. Houghton, Mifflin.

Reid. *Pond Life*. Golden.

Robbins. *Birds of North America*. Golden.

Smith. *Handbook of Lizards*. Comstock Publishing.

Sprunt. *Gamebirds*. Golden.

Stebbins. *Amphibians and Reptiles of North America*. McGraw Hill.

Zim. *Fishes—A Guide to Familiar American Species*. Golden.

Zim. *Insects*. Golden.

Activities:

Suggested for use by teachers.

Brown. *How to Follow the Adventures of Insects*. Little, Brown. An excellent introduction to scientific study of insects.

Brown. *How to Make a Home Nature Museum*. Little, Brown. Hundreds of natural history activities to establish a collection. Collecting, preserving, preparing, displaying.

Brown. *How to Make a Miniature Zoo*. Little, Brown. How to collect, care for, cage, and display small animals—tools, techniques, species, plans—a pocket manual.

Callahan. *Insect Behavior*. Four Winds. The diverse and ingenious ways that insects have adapted to environments. Many projects and experiments.

Cooper. *Science in Your Own Backyard*. Harcourt, Brace. Exploring your backyard—animal, vegetable, and mineral. Learning to work out answers to natural history questions. Excellent project and activity material.

Cunningham. *First You Catch a Fly*. McCall. Very interesting series of experiments introducing the fly, its life history, habits, and habitat.

Facklam. *Science Museum Makers*. Rand McNally. The fascinating behind-the-scenes of a natural history museum. How's it done? Maybe you would like to work here.

Headstrom. *Adventures with a Hand Lens*. Lippincott. Fifty "adventures" with a hand lens. Plants and animals—opening a whole new world of investigation.

Headstrom. *Adventures with Freshwater Animals*. Knopf. A series of "adventures" in the study and understanding of freshwater animals. Probably junior high level.

Headstrom. *Lizards as Pets*. Lippincott. An excellent introduction to lizards, with notes on collecting, care, handling, and study.

Headstrom. *Nature in Miniature*. Knopf. A tremendous and unique guide to "things" in the out-of-doors. Things we have looked at but never "seen." Adventures with a hand lens.

- Kaston. *How to Know the Spiders*. Brown and Company. Pictured—key for more common spiders. Suggestions regarding study and collection.
- Leskowitz. *Animals are Like This*. Prentice Hall. Experiments you can perform with animals. Simple exercises fitted for the classroom.
- Lindeman. *Water Animals for Your Microscope*. Crowell, Collier. How to find, collect, identify varied water animals. Experiments to perform with them.
- Parsons. *How to Make Earthworms Pay*. Abelard, Schuman. An interesting book outlining a project for fun or for money. All instructions on how to raise worms.
- Pinney. *Collecting and Photographing Your Microzoo*. World. Collecting, caring for, preparing and photographing microorganisms.
- Pringle. *Discovering Nature Indoors*. Natural History. Projects and activities, with nature, indoors. Investigations and studies; well illustrated.
- Pringle. *Discovering the Outdoors*. Doubleday. A better-than-average introduction to natural history with projects and activities.
- Pray. *Taxidermy*. MacMillan. A manual for the amateur—how to, tools, procedures.
- Reynolds. *The Pond on My Windowsill*. Pantheon. A clear and concise guide to setting up an insect aquarium.
- Schwartz. *Life in a Drop of Water*. Natural History. A really fascinating introduction to the microscopic worlds in drops of water. Fine illustrations. Plants and animals—how to do it yourself.
- Simon. *Animals in Field and Laboratory*. McGraw Hill. Very good projects to study animal behavior with common animals. Experiments cover senses, animal clocks, animal migration, etc.
- Simon. *Discovering What Goldfish Do*. McGraw Hill. Some simple studies and activities which could be done in classrooms.
- Smith. *Hunting Big Game in the City Parks*. Abingdon. Adventures with the insect world told in narrative style with directions for do-it-yourself.
- Teale. *Junior Book of Insects*. Dutton. Well-written life history information on many insects with sections on collecting, rearing to study.
- Waitley. *My Backyard*. David White. An interesting introduction to what can be found in a 30-foot by 70-foot backyard, and the lessons that can be found there. The cell, sprouting seeds, evolution, bird psychology, and migration.

Life Histories:

For student reading—pleasure or research.

Allen. *Wildlife Legacy*. Funk and Wagnalls. The standard on wildlife management. Very readable.

Austing. *The World of the Red-Tailed Hawk*. Lippincott. Very good life history. Well illustrated.

Austing and Holt. *The World of the Great Horned Owl*. Lippincott. Fine life history. Well illustrated.

Aylesworth. *Into the Mammal's World*. Natural History. Very fine stories about wildlife biologists and their studies. Good reading and factual.

Bardach. *Downstream*. Grosset and Dunlap. The natural history of a river; almost a field guide. How a river "works"—rivers and history—repairing damage—a most unusual book.

Barkalow and Shorten. *The World of the Gray Squirrel*. Lippincott. Good life history of a common animal. Well illustrated.

Barker. *Familiar Reptiles and Amphibians of America*. Harper and Row. Very readable natural history of these animals. Apparently well-documented life history on many species.

Beebe. *American Desert Animals*. McKay. Very good introduction to some Southwestern animals—good life history and interesting stories.

Billington. *Understanding Ecology*. Fredrick Warne and Company. Simple, basic introduction to Ecology—can be used by mid- and upper-elementary and high school.

Bjorklund. *Bison—The Great American Buffalo*. World. Beautifully illustrated, well-told story of the buffalo.

Boughey. *Ecology of Populations*. Macmillan. Environmental requirements of organisms, organization of communities, population characteristics, interaction and evolution.

Brandhorst. *The Tale of Whitefoot*. Simon and Schuster. The energy cycle well told in the story of a mouse.

Buck. *In Yards and Gardens*. Abingdon. An introduction to living things in your yard and garden. Very well illustrated.

Busch. *Exploring As You Walk in the City*. Lippincott. Simple book on sidewalk ecology. Primary.

Busch. *Exploring As You Walk in the Meadow*. Lippincott. Simple book on meadow ecology.

Calahane. *Alive in the Wild*. Prentice Hall. Outstanding stories of wild animals by wildlife biologists.

- Carr. *The Reptiles*. Time, Inc. An excellent and beautifully illustrated natural history of reptiles.
- Carson. *Silent Spring*. Houghton, Mifflin. The classic introduction to pesticide effects on our world. Discusses dramatic effects upon wildlife.
- Cole. *Cockroaches*. Morrow. Life history and facts about a much misunderstood insect. Well illustrated.
- Collier. *Three Against the Wilderness*. Dutton. The amazing true story of a modern pioneer family and the miracle they wrought in a barren northern wilderness.
- Cooper. *A Chipmunk's Inside-Outside World*. Messner. Excellent, simple life history of a chipmunk. Beautifully illustrated.
- Costello. *The World of the Ant*. Lippincott. Excellent life history of the ant. Well illustrated and in-depth.
- Costello. *The World of the Gull*. Lippincott. Life history of an interesting bird. All aspects of life cycle. Excellent illustrations. Ecology of an aquatic bird.
- Costello. *The World of the Porcupine*. Lippincott. Very good life history. Well illustrated.
- Costello. *The World of the Prairie Dog*. Lippincott. An excellent life history and year in the life of a prairie dog. Fine photography.
- Cox. *Readings in Conservation Ecology*. Appleton, Century Crofts. An ecosystem approach to conservation problems. Articles by outstanding people in the field.
- Craighead, Frank and John. *Hawks, Owls, and Wildlife*. Stackpole. The authoritative report on the subject of raptures versus other wildlife.
- Crompton, John. *The Life of a Spider*. Mentor. One of the most fascinating books of its type. Will give you a completely new outlook on spiders.
- Curtis. *The Life Story of the Fish*. Brian, Dover. A fascinating introduction to the world of fishes—"his manners and morals."
- Darby. *Jerry Finds Spiders*. Simple well-illustrated introduction to spiders and how to study them.
- Dasman. *Wildlife Biology*. Wiley and Sons. One of the best introductions to wildlife management by one of the best writers on the subject.
- Dasman, Raymond. *If Deer are to Survive*. Stackpole. A top biologist speaks in realistic terms about wildlife management.
- Deseyn. *Termite Works for his Colony*. Holiday House. Complex life history of a termite; simply told and well illustrated.
- Doerling. *An Ant is Born*. Sterling. Very short, but good introduction to the life history of an ant. Excellent photographic illustrations.

- Doerling. *A Bee is Born*. Sterling. Very good life history of bees; well illustrated; intermediate level.
- Durrel. *Birds, Beasts and Relatives*. Viking. Gerry, the ten-year-old naturalist explores a wild island and collects creatures for his private zoo.
- Eberle. *Fawn in the Woods*. Crowell. Simple, elementary narrative of the first year in the life of a deer. Outstanding photography illustrations.
- Ehrenfeld. *Biological Conservation*. Holt, Rinehart and Winston, Inc. The relationships between ecology and conservation—the impacts of the population and technology explosions on the natural world.
- Eschmeyer. *Bob White*. Fishermen's. Excellent life history of a Bob White quail. Brings out conservation concepts.
- Eschmeyer. *Bobby Bluegill*. Fishermen's. Excellent life history of a fish—habitat and conservation.
- Errington. *Of Predation and Life*. Iowa State University Press. A presentation, in popular form, of research on predator-prey relationships and the necessity of predators to the biological community.
- Farb. *Ecology—Life Nature Library*. Time, Inc. An excellent and beautifully illustrated introduction to ecology—webs, rhythms and cycles, mutualism, population dynamics—man.
- Fichter. *Fishes*. Golden. A beautifully illustrated introduction to the fishes.
- Fisher. *Valley of the Smallest—The Life Story of a Shrew*. Crowell. An excellent life history weaving in interrelationships, plant succession, predation, and the shrew's part in it all.
- Foster. *Close-up of a Honeybee*. Young, Scott. A different type of introduction and life history; excellent photography.
- Freedman. *Animal Architects*. Holiday House. The elaborate shelters, nests, and dens constructed by animals.
- Freschet. *Beaver on the Sawtooth*. Crowell. A little different approach to a life history—man using wildlife in a beneficial way.
- Freschet. *The Jumping Mouse*. Crowell. Nicely told narrative life history of a jumping mouse.
- Gannon. *What's Under a Rock?* Dutton. Under-rock-ecology. Interesting narrative of what life exists under a rock and in the soil.
- George. *Bubo—The Great Horned Owl*. Dutton. Excellent natural history of a great horned owl written by a wildlife biologist.
- George. *The Moon of the Chickarees*. Crowell. Very well-told life history of the chickaree and his neighbors.

- George. *The Moon of the Moles*. Crowell. Very well-told narrative life history of a strange animal.
- George. *The Moon of the Owls*. Crowell. January, the month of the owl—well told; ecologically sound.
- George. *The Moon of the Winter Bird*. Crowell. Excellent, ecologically-oriented narrative of life of a song sparrow.
- Goodall. *My Friends, the Wild Chimpanzees*. National Geographic Society. A woman biologist lives with and studies chimpanzees in the forests of Tanzania. She describes how chimps communicate, work and play, and make and use tools.
- Hamilton. *Among the Elephants*. Viking Press. The true story of a young biologist and his wife studying elephants in Tanzania.
- Harris. *Slim Green*. Little, Brown. Excellent little story of interrelationships of animals. Primary level, but well done.
- Harrison. *The World of the Snake*. Lippincott. Very good life history. Well illustrated.
- Hess. *The Praying Mantis, Insect Cannibal*. A beautifully illustrated life history of the mantis; some activities.
- Hester and Dermid. *The World of the Wood Ducks*. Lippincott. Good life history of our most beautiful duck. Well illustrated.
- Hutchins. *The Mayfly*. Addison, Wesley. Beautifully illustrated life history told in narrative form.
- Hutchins. *The World of Dragonflies and Damselflies*. Dodd, Mead. An excellent introduction to the species; beautifully illustrated. A section on collecting and studying.
- Ipsen. *Rattlesnakes and Scientists*. Addison Wesley. Excellent information on rattlers told in narrative form. Very readable.
- Kaufmann. *Chimney Swift*. Morrow. Good life history of one of our most unusual birds. Good chapter on banding.
- Lauwerys. *Man's Impact on Nature*. Natural History. Man versus nature—man the hunter, herdsman, cultivator, predator, the machine age, overpopulation, poisoned environment.
- Lavine. *Wonders of the Bat World*. Dodd, Mead. Quite extensive life history of the wapiti and his future. Beautifully illustrated.
- Laycock. *The Alien Animals*. The Natural History Press. The story of imported wildlife and the bizarre things that can happen when they are introduced into a new world.
- Laycock. *Whitetail*. Norton. Excitingly told tale of a whitetail buck. Good natural history, true to life.

- Leopold. *The Desert. Time*. An excellent introduction to desert ecology by an outstanding wildlife biologist.
- Leopold. *Sand County Almanac*. Sierra Club-Ballentine. Some of the finest and most beautiful writing on wildlife, ecology, and the environment. Short essays—very usable in literature, social studies, and science.
- Leopold. *Wildlife of Mexico*. University of California Press. A survey of wildlife in Mexico by one of America's leading wildlife biologists.
- Lewellen. *The True Book of Honeybees*. Children's Press. Primary introduction to the world of bees. Well done.
- Lewis. *The World of the Turkey*. Lippincott. Good life history of a familiar bird; good illustrations.
- Lowe. *Arizona's Natural Environment*. University of Arizona Press. Landscapes, habitats, communities, succession—plants and wildlife.
- Lubell. *Birds in the Street*. Parents' Magazine. Very fine introduction to pigeons and the problems they create in cities. Good discussion of pros and cons. Solutions to overpopulations discussed.
- MacArthur. *UHU*. Knopf. Story of a baby owl raised in captivity—with the usual sad ending. A story that needs to be told.
- Marshall, Munson and Phillips. *Birds of Arizona*. University of Arizona Press. The best current book available on the birds found in our State.
- Mason. *Animal Teeth*. Morrow. Very good introduction to the importance of teeth—identification of animals, aging, what they eat, etc.
- May. *Bats*. Meredith. What we know about bats: legend, superstition, and fact. Natural history of bats; the research being done on bats.
- McClung. *Lost Wild America*. Morrow. A very good summary of our extinct and vanishing wildlife. Good statement as to where the fault lies.
- McClung. *The Mighty Bears*. Random House. Very good, factual information and introduction to bears.
- McClung. *Spotted Salamander*. Morrow. Good, elementary life history of a salamander.
- Mech. *The Wolf*. Natural History Press. A study of the ecology and behavior of an endangered species.
- Mech. *The Wolves of Isle Royal*. U. S. Government Printing Office and Natural History Press. Outstanding study of moose-world relationships—predator-prey.
- Milne. *The Ages of Life*. Harcourt, Brace and World. What is growth and how does age effect? The detailed patterns in living things. Excitingly told by an outstanding team of naturalists.

- Milne. *Paths Across the Earth*. Harper. A team of noted naturalists tell the intriguing story of animal migrations, and of the ways in which life spreads over our world.
- Milne. *The Secret Life of Animals*. Dutton. Fascinating stories of animal behavior.
- Milne. *The World of the Night*. Harper. Fascinating observations of animals that travel by night. What happens under the cover of darkness.
- Milotte. *The Story of an Alaskan Grizzly Bear*. Knopf. Very well-told story and life history of a grizzly. Authentic and interesting.
- Mowat. *Never Cry Wolf*. Little, Brown. A wildlife biologist spends a summer studying wolves. One of the funniest books you will ever read.
- Murie. *A Naturalist in Alaska*. Devin-Adair. Living with and studying wolves, grizzly bears, and other animals in Alaska.
- Murie. *Wapiti Wilderness*. Knopf. The Wyoming adventures of a wildlife biologist studying elk.
- Museum of Natural History, The. *Field Studies in Natural History*. The Museum of Natural History. Naturalists, working in the field; their adventures, problems, and what they are learning.
- National Geographic Society. *Song and Garden Birds of North America*. National Geographic Society. Habits and habitats for 327 species of birds and how to attract them to home or campus.
- Osteen. *Bears Around the World*. Coward, McCann. Very well written, comprehensive introduction to bears.
- Pain. *Grassblade Jungle*. Coward, McCann. In-depth, natural history and fascinating information on six species: grasshoppers, mantids, bees, cicadas, termites, and scorpions.
- Park. *The World of the Bison*. Lippincott. An excellent life history of the bison, his past and future. Beautifully illustrated.
- Park. *The World of the Otter*. Lippincott. Very good life history. Well illustrated.
- Peterson. *Silently, by Night*. McGraw Hill. Narrative, personal anecdote and scientific study, interestingly told. Filled with facts about bats around the world.
- Pond. *Survival in Sun and Sand*. Norton. An interesting study of deserts, their ecology and life, water, survival, adaptation, etc.
- Porter. *The World of the Frog and the Toad*. Lippincott. An excellent, well-illustrated introduction to these common animals.
- Pringle. *Wild River*. Lippincott. A beautiful book on the ecology of a river.
- Rawlings. *The Yearling*. Scribners. The beautiful story of Jody and his fawn and their life in the Florida swamps. A classic.

- Ripper. *Moles and Shrews*. Morrow. Very good presentation of two almost unknown but fascinating animals.
- Roberts. *Red Fox*. Houghton, Mifflin. Fictionalized life history, beautifully told. A little unrealistic and anthropomorphic, but a good tale well told.
- Roever. *The Rascally Ringtails*. Steck, Vaughn. A very well-done introduction to three species: raccoon, ringtail, and coati. Brief but good life history. Excellent illustrations.
- Rorabacher. *The American Buffalo in Transition*. North Star. A historical and economic survey of the bison in America. What was the resource, what really happened and why, and what is the future.
- Rosen. *Spiders are Spinners*. Mifflin. Beautiful introduction to spiders. Takes away fear and creates interest. Fine illustrations.
- Rosen. *To Be a Bee*. Mifflin. Excellent, simple introduction to bees, probably primary use. Beautifully illustrated; should stir interest.
- Rue. *The World of the Beaver*. Lippincott. Very good life history. Well illustrated.
- Rue III. *The World of the Raccoon*. Lippincott. Very good life history. Well illustrated.
- Rue III. *The World of the Red Fox*. Lippincott. Very good life history. Well illustrated.
- Rue III. *The World of the White-Tailed Deer*. Lippincott. Very good life history. Well illustrated.
- Russell. *City Critters*. Merridith. An interesting depiction of wildlife in large cities—how they have adapted and thrive living with man.
- Russell. *Clarion the Killdeer*. Hawthorne. Good narrative life history of an interesting and common bird.
- Schaller. *The Deer and the Tiger*. University of Chicago Press. A biological study of the interrelationships of the deer and tiger in India.
- Schaller. *Golden Shadows, Flying Hooves*. Knopf. The personal story and adventures of a wildlife biologist in Africa. His studies of the lion, leopard, cheetah, wild dog, and hyena on the Serengeti plains.
- Schisgall. *That Remarkable Creature the Snail*. Messner. Simple, well-explained and illustrated introduction to snails.
- Shuttlesworth. *The Story of Flies*. Doubleday. An excellent look at the diptera and their value to man, as well as their negative aspects. Good illustrations.
- Shuttlesworth and Swain. *All Kinds of Bees*. Random House. Primary introduction to the world of bees. Well done and illustrated.
- Silverstein. *Rats and Mice—Friends and Foes of Man*. Lothrop, Lee and Shepard. An excellent study of animals most despised by man. Shows values of, as well as dangers of. Very interesting. Well illustrated.

- Soule. *Strange Things Animals Do*. Putnams. Interesting stories of man's study of animals in the field. Up-to-date.
- Stefferd. *Birds in Our Lives*. U. S. Department of Interior. Birds as they affect and are affected by people, other birds, and other forms of life and activities.
- Storer. *The Web of Life*. Devin, Adair. A simple, elementary book on the fundamentals of ecology. Outstanding book.
- Tinbergen. *Animal Behavior*. Time-Life. Beautifully illustrated introduction to the study of wildlife behavior, by one of the world's top animal behaviorists.
- Trost. *A Cycle of Seasons—The Little Brown Bat*. Young, Scott. Simple, very nicely told year in the life of a bat.
- VanWormer. *The World of the American Elk*. Lippincott. An excellent life history of the wildpiti and his future. Beautifully illustrated.
- VanWormer. *The World of the Black Bear*. Lippincott. Excellent life history. Well illustrated.
- VanWormer. *The World of the Bobcat*. Lippincott. Very fine life history. Well illustrated.
- VanWormer. *The World of the Canada Goose*. Lippincott. Very good life history. Well illustrated.
- VanWormer. *The World of the Coyote*. Lippincott. Excellent life history—natural history of the coyote. Great photographic illustrations. Accurate and authentic.
- VanWormer. *The World of the Pronghorn*. Lippincott. Excellent life history. Well illustrated.
- VanWormer. *The World of the Swan*. Lippincott. Fine life history of a beautiful bird. Good illustrations.
- Ward. *The Biggest Bear*. Riverside. A story that needs to be told more often: that wildlife should be wild. Quite elementary.
- White. *A Frog is Born*. Sterling. Very good, well-illustrated life history. Intermediate level.

Periodicals:

- American Association for Advancement of Science. *Science* (magazine). A rather technical magazine of general science issues.
- American Fisheries Society. *Transactions of American Fisheries Society* (journal). Technical journal about fish and their environments.
- American Institute of Biological Sciences. *Bio-Science* (magazine). A rather technical magazine dealing with all areas of biological sciences—but excellent material.
- American Museum of Natural History. *Junior Naturalist* (magazine). A children's magazine of general natural history—a good source of material and activities.

American Museum of Natural History. *Natural History* (magazine). An excellent magazine on natural history.

American Ornithological Union. *The Auk* (magazine). A magazine specializing in bird information—rather technical.

American Society of Mammologists. *Journal of Mammology* (journal). The official journal of the Society of Mammologists—rather technical.

Arizona Game and Fish Department. *Wildlife Views* (magazine). General articles on Arizona wildlife, ecology, and environment.

Arizona Wildlife Federation. *Sportsmen's News* (newspaper). Monthly newspaper of Arizona sportsmen; good ecology and environmental information about Arizona.

Conservation Foundation. *C. F. Letter* (bulletin). (Free) General bulletin of all areas of conservation and environment.

Cooper Ornithological Society. *Condor* (magazine). A magazine for the bird specialist—a little technical.

National Audubon Society. *Audubon* (magazine). A most beautiful magazine dealing with all elements of conservation, ecology, and environment.

National Wildlife Federation. *Conservation Directory*. (Free) An excellent weekly news bulletin on conservation, ecology, and environment.

National Wildlife Federation. *Conservation News*. (Free) An excellent weekly news bulletin on conservation, ecology, and environment.

National Wildlife Federation. *Conservation Report*. (Free) An excellent free source of information on conservation and environment.

National Wildlife Federation. *International Wildlife* (magazine). A very beautiful and excellent magazine about international wildlife.

National Wildlife Federation. *National Wildlife* (magazine). A very beautiful and excellent magazine about American wildlife.

National Wildlife Federation. *Ranger Dick* (magazine). Generally excellent children's magazine on wildlife—a little too anthropomorphic.

Natural History Society. *Naturalist* (magazine). An excellent magazine on natural history.

Phoenix Publishing, Inc. *Outdoor Arizona* (magazine). A magazine about Arizona hunting, fishing, and outdoors.

Scientific American, Inc. *Scientific American* (magazine). "The" magazine on general science material—technical.

Sport Fishing Institute. *SFI Bulletin* (bulletin). (Free) A good news bulletin on fish and their habits.

Wildlife Management Institute. *Outdoor News* (bulletin). (Free) A general bulletin of conservation and environmental news.

Wildlife Society, The. *Journal of Wildlife Management* (journal). The official journal of the Wildlife Society—rather technical.

Pamphlets:

Arizona Game and Fish Department. *Arizona Game Bulletins*. (Free) Simple life history information on Arizona species.

Arizona Game and Fish Department. *Boom and Bust*. (Free) The story of the Chiricahua whitetail deer.

Arizona Game and Fish Department. *Fatal Future*. (Free) Dredging and channelization of rivers and effects on wildlife.

Arizona Game and Fish Department. *Habitat*. (Free) Wildlife's most important need—and most dangerous loss.

Arizona Game and Fish Department. *Now That You've Got It, What Are You Going To Do With It?* (Free) How to clean, skin, and prepare wildlife for eating.

Arizona Game and Fish Department. *Our Bobwhites Come Home*. (Free) An extinct species restored to Arizona.

Arizona Game and Fish Department. *Quail Research in Arizona*. (Free) The findings and results of many years of research on quail.

Arizona Game and Fish Department. *Survival*. (Free) Very brief introduction to survival.

Arizona Game and Fish Department. *The Terrible Lesson of the Kaibab*. (Free) The results of mismanagement of wildlife.

Arizona Game and Fish Department. *Values of Hunting and Fishing in Arizona*. (Free) The dollars and cents of hunting and fishing in our economy.

Arizona Game and Fish Department. *Western Hawks*. (Free) An identification chart and information on foods of hawks.

Arizona Game and Fish Department. *Wildlife—The Environment Barometer*. (Free) Wildlife as an indicator of environmental quality.

Arizona Game and Fish Department. *The Wildlife Manager*. (Free) What is a wildlife manager? What does he do? Requirements?

National Shooting Sports Foundation. *The Hunter and Conservation*. (25¢) What the hunter has done for wildlife.

Olin-Matheison Corporation. *For the Young Hunter*. Olin-Matheison Corporation, East Alton, Illinois. (25¢) The ethics and code of the hunter.

Olin-Matheison Corporation. *Game, Gunners and Biology*. Olin-Matheison Corporation, East Alton, Illinois. (25¢) An excellent statement of the relationships between hunters and wildlife.

Olin-Matheison Corporation. *Principles of Game Management*. Olin-Matheison Corporation, East Alton, Illinois. (25¢) Simple statement of what wildlife management is.